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Modèles de négociation client-fournisseur dans une chaîne logistique collaborative

RESUME: Au sein de chaînes logistiques, les conflits pouvant exister entre d'une part l'autonomie et la coopération, et d'autre part entre des objectifs locaux et globaux, définissent un contexte très complexe auquel les membres d'une même chaîne doivent faire face, surtout lorsque les entreprises sont impliquées dans des chaînes d'approvisionnement multiples ou des réseaux. Par ailleurs, ces problèmes sont de nature à provoquer une dégradation de la performance de la chaîne logistique, notamment dans un contexte de fabrication aussi complexe que celui du secteur aéronautique. De ce fait, organiser et bien gérer les relations inter-partenaires devient un facteur important de performance dans une chaîne logistique. Dans ce contexte, ce travail vise à proposer des modèles de négociation client/fournisseur en vue d'aider à la formalisation de contraintes cachées, dans l'optique de partager les risques entre partenaires et de faciliter de la sorte la synchronisation entre besoins locaux et impératifs globaux. Afin de rendre notre proposition réaliste, nous avons tout d'abord détaillé des processus de négociation puis testé leur faisabilité pratique, d'une part par des exemples d'évaluation des coûts engagés et d'autre part en les positionnant par rapport aux situations de coopération dans lesquelles ces processus de négociation peuvent exister.

Mots clé: chaîne logistique, coopération, négociation, performance, partage de risque

Models for customer-supplier negotiation in a collaborative supply chain

ABSTRACT: In supply chains, the conflicts between autonomy and cooperation, local interest and global objective are important problems that supply chain members are currently facing, especially when enterprises are involved in multiple supply chains or networks. Furthermore, the growing complexity of supply networks has extended the risks of poor supply chain performance, particularly for complex manufacturing, such as aeronautic industry. Thereby, building and managing a good relationship between partners is an essential factor for supply chain performance. In this context, we suggest a negotiation process, helping supply chain member to publish hidden constraints, synchronize internal and external interests, and share risks with other supply chain members, finally improving the performance of cooperation. In order to make our suggestion realistic, we have firstly specified the detailed processes and then tested their practical feasibility, on one hand through the assessment of extra costs and on the other hand by matching them with identified cooperation situations, in which such negotiation process may exist.

Key words: supply chain, cooperation, negotiation, performance, risk sharing

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Contents

List of Figures:

List of Tables:

Introduction

Nowadays, market environment is changing rapidly. Global purchasing and international manufacturing are very common situations. The ever changing customer's requirements and various customizations of products are more and more challenging the manufacturers. In that context, manufacturers are facing difficulties to earn money through producing goods at the best price, providing at the required time and in the required quantity. Therefore, manufacturers often choose to focus on their core business and take part in supply chains for obtaining from external partners the competences they do not have anymore. Ever since then, the interest of supply chains is widely recognized, which emphasizes the necessity to better address the conditions of an efficient co-working between partners within supply chains.

Pushed by globalization and its consequent increased competition, supply chain managers have understood the importance of information sharing, joint decision-making, building effective partnership, and cooperation across supply chains. However, performing effective cooperation and maintaining good relationship are not easy tasks in the real practice, since the supply chain members are autonomous entities, pursuing their benefits based on local interests. Therefore, how to synchronize local activities through global processes, how to balance internal interests and overall objectives of the supply chain, and how to establish cooperative supply chain relationships are actual difficulties that supply chain members have to address. These problems are especially important in the aeronautical sector, in which many partners of different competence, size and culture are involved in more and more complex networks.

During the last few years, our research team has been involved in several projects aiming at analyzing or improving cooperation in supply chains, among which the main one was performed with funding from an association of companies of the aeronautic industry and from a public body interested in Small and Medium Enterprises (SMEs) development. The objective of the project was to analyze the problems linked to the cooperation between partners of aeronautical supply chains, especially when SMEs were involved.

In aeronautical supply chains, the difference between large enterprises and SMEs is emphasized due to the huge gaps between them, of course in terms of size or type of product, but also decision-making policy, production management tools, etc. In SMEs, the planning process may be less formal, and multi-functional planning takes place within individual minds. Managers and operatives are more likely to be directly involved with the customers. Two-way and face-to face communication is the norm in SMEs. Additionally, SMEs are more likely to be "people oriented" rather than "system oriented", therefore SMEs are less oriented on information technology and management tools allowing long/middle term visibility.

We have also seen during the case studies that many practices exist which differ from "theoretical" supply chain management principles, in an open way when they come from the customers, but in a more hidden way when they come from the suppliers, who often heavily depend on their customers.

In addition, we have quite often seen during the interviews that people were putting some emphasis on other issues than purely technical ones, often speaking of trust, maturity, involvement, goodwill etc. Looking back to the cases, the denoted practices are often linked to specific situations: relative weakness of a supplier, dependence of a customer towards his supplier, trust (or distrust) between partners, etc. It seems to us that these conditions are closely attached to different types of supplier-customer relationships and cooperation situations in the supply chain.

Two approaches are possible when considering these problems: many customers, aware of them, consider that they are the proof of a lack of maturity of their suppliers (and sometimes of themselves). For them, the solution is then to increase this maturity through "supplier development". In that purpose, many projects have been launched during the last five years aiming for instance are disseminating the principles of MRP and lean management in the SMEs of the aeronautic sector. This is indeed a long term approach, and we have decided in this thesis to explore another direction: for us, practices (even if they may have negative consequences) are linked to actual needs, closely attached to the relationship between supplier and customer. Therefore, the idea is to accept to analyze practices which are not consistent with present industrial habits, in order to better formalize them and objectively assess their possible area of interest.

In this thesis, we suggest a series of negotiation processes, aiming at helping supply chain member to turn some of their hidden practices into negotiable items, in order to balance their local interests with those of the whole supply chain, and accordingly share information/risks and better cooperate with the other partners. Since our suggestions are mainly based on the results of our case studies in the aeronautic industry, the outcome of our proposals should hopefully be close to real practices.

The thesis is structured as follows:

In Chapter 1, a literature view on the context of supply chain is presented. We firstly introduce the concept of supply chain, including material flows and information flows, under different types of characteristic structures, especially in aircraft manufacturing industries. Secondly, we stress the concept of supply chain management and identify the existing models of supply chain management processes, tools and methods. With the present industrial context of sensitive competition, coordination, cooperation and collaboration between partners is emphasized as a key point for improving supply chain performance. We explain the conditions for cooperation in the last part of this chapter, which are identified as openness, mutual respect and trust, information sharing, jointly planning, resulting in improved customer-supplier relationship.

In Chapter 2, case studies from the aeronautical industry are introduced, showing possible gaps between the theoretical principles and the real practices. We highlight some good practices in which cooperative supply chain members share information and perform protection actions based on real needs, instead of rigidly executing the contracts between partners. We also show some practices aiming at satisfying local interests which may prevent from a good performance of the global supply chain. Good or bad, we have chosen to take into account these practices in order to suggest more cooperative management processes, based on negotiation.

In Chapter 3, we choose to firstly formalize the negotiation processes based on lessons learnt from the identified practices. Accordingly, we have chosen to focus on four aspects:

periods of forecast, load variation, price and cycle time, and order priority and lot size, and consider them as the objects of our suggested negotiation processes. Then, we bring out brief descriptions of these processes using business process models then specify the activities of the processes using UML sequence diagrams, trying to provide a clear view on:

- *When is there a need to negotiate these items?*
- *At which level should these negotiations be handled?*
- *What is needed to perform such negotiations?*

In addition, we give a short focus on the extra costs induced by negotiation, which are of course the main results allowing to assess its possible interest.

In Chapter 4, as an illustration, we provide some numerical simulations of exchanges between partners at different levels (S&OP, MPS, and MRP), comparing the total cost/benefits of the normal case(s) and negotiation-based case. The results show the possible interest of negotiation, but of course not its technical and social feasibility. Indeed, a condition for adopting these processes is that the supply chain members are ready to go beyond their local interests, which, in our opinion, may paradoxically lead to win-win situations.

In Chapter 5, we analyze this important constraint on the negotiation processes, which require a mutual trustful climate through real information sharing, actual constraints publishing, etc. Thereby, we identify a taxonomy of the cooperation situations based on existing ones and on important factors considered as impacting customer-supplier relationship in the literature. Then, we match the identified situations with our negotiation processes, trying to test the usefulness of the taxonomy of the cooperation situations, or on the opposite to identify the situations required by the negotiation processes. Finally, we briefly present some possible evolutions of the situations, showing that the suggested typology may help to have a better view on the dynamics of customer-supplier relationship, and accordingly of the negotiation processes.

At the end, we conclude the presented work in a general conclusion and address the perspectives and further steps in the future.

Chapter 1
Literature View

To study the performance of a Supply Chain (SC) or Supply Network (SN), it is necessary to analyze the behavior of each entity (i.e. each partner) but also to analyze the link between the local performance of each entity and the global performance of the chain. Since each member may be an individual organization having its own autonomy and business strategies, making them cooperate on the base of common objectives is a major issue, which has been widely addressed in the literature. In order to better explain the underlying problems, we give an overview of the issues on supply chain cooperation in this chapter.

1 Context of Supply Chain

Nowadays, market environment is changing rapidly. Global purchasing and international manufacturing become common situations, while the ever changing customer's requirements and increased customization of the products create new difficulties for the manufacturers. For being more competitive, a possible answer is that the companies may focus on their core business, and take part in supply chains for obtaining from external partners the competences they do not have. Therefore, the interest of supply chains has increased through years, emphasizing the interest on the conditions of co-working between partners.

1.1 Concept of supply chain

1.1.1 Definitions of a supply chain

Many definitions of a supply chain can be found in the literature, but they share many common points. The most popular definition is perhaps given by Christopher (1992):

"*The network of organization that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the end customers.*"

The use of the term "network" suggests that the companies involved in a supply chain could not only perform complementary activities but also pursue common objectives. Such common objectives stress that all the activities along a supply chain should be designed according to the needs of the customer to be served. As a consequence, the (ultimate) customer is at best an integral part of a supply chain (Stadtler, 2005). Normally, many independent firms belonging to a supply chain are involved for manufacturing a product and placing it in the hands of the end user (La Londe and Master, 1994). Raw material and components producers, product assembler, wholesalers, retailers and transportation companies are all members of a supply chain. These members are divided into upstream and downstream partners according to their position relative to a given enterprise (see Figure 1.1).

Other similar definitions are also provided by Lee and Billington, (1993); Mentzer et al., (2001); Min and Zhou, 2002; Swaminathan and Tayur, (2003).

Some definitions of a supply chain are given not only considering the transformation of product or service, but also emphasizing the information flow, such as the ones of Govil and Proth, (2001) or Mahmood et al., (2003). They consider two distinct flows: product/material flows and information flows through the organization (see Figure 1.1).

A supply chain is a global network of organizations that cooperate to improve the flows of material and information between suppliers and customers at the lowest cost and the highest speed. The objective of a supply chain is customer satisfaction (Govil and Proth, 2001).

Supply chain encompasses all activities associated with the flow and transformation of goods and services as well as the attendant information flows from suppliers of raw material and components through manufacturing/assembly plants, through the distribution chain (transporters, warehouses, distribution centers, retailer), and down to the customers/ end user (Mahmood et al., 2003).

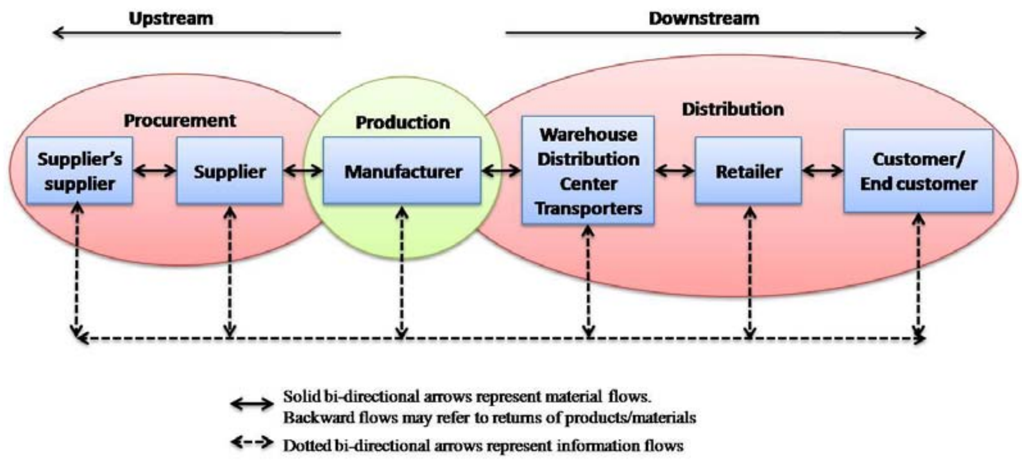

Figure 1.1. Supply chain entities and flow (Chen and Paulraj, 2004, Mahmood et al. 2003)

The product flow includes the movement of goods or services from a supplier to a customer, as well as any customer returns or service needs. The information flow involves transmitting orders/demand, updating statues of inventory, and technical data if necessary, such as capacity, schedule etc. Normally, the information is viewed as a main flow in the opposite direction of products, meaning that information mainly moves upstream whereas products mainly move downstream.

Several authors include strategic decision making as a different emphasis aspect of a supply chain definition. For example, Oliver and Webber (1992) state that a supply chain should be viewed as a single entity guided by strategic decision making. Each chain member's performance is impacted by the quality of other supply chain members' decision making (Stecke et al., 2004). Besides, another definition considers the contract as an element of the supply chain which could control the material flow over a longer horizon (Swaminathan et al., 1998). For instance, Christopher (1998) stresses that a supply chain consists of a "network of organizations involved through upstream and downstream contract linkages, with each organization performing different processes and activities."

From these various definitions of a supply chain, it could be outlined that the involved entities are normally suppliers, manufacturers (assemblers), distributors, retailers and end customers. They have a clear division of work, from delivering raw materials/processing semi-finished product/ producing finished product, to distributing to retailer or end customers. All of these works compose the product flow of a supply chain, transforming raw materials into final delivered products towards the end customer. Meanwhile, these individual entities are connected based on their agreements on demand and supply in terms of price, quantities, delivery time and etc., usually called "contract". Their local processes are partially integrated aiming at shorten the entire delivery time towards the customers and locally being more efficient. On the other hand, the information flow throughout the chain is an essential support that helps the supply chain members to act, make decisions and balance local perspectives and global interest. Transforming raw materials and components into finished products should be accompanied with sharing information on technical data, critical parameters, constraints, etc. in order to ensure that the local processes of different members are working concurrently and are capable to meet the global objectives.

1.1.2 Structure of a supply chain

The supply chain structure represents how business enterprises are organized, by upstream and downstream links, to form a supply chain. Several authors have achieved works on the classification of the supply chain structure. For instance, Huang et al., (2003) identify five perspective of supply chain structure: dyadic, serial, divergent, convergent, and network. Another more specific work is provided presenting four similar supply chain structures: convergent, divergent conjoined and network (Beamon and Chen, 2001). In these classifications, the network structure is different from other traditional structures since there is no clear tier boundary for each supply chain members. In a network structure, one supply chain member can be in multiple tiers, whereas one member should be in one certain tier in other structures, like serial, convergent, divergent and conjoined (see Figure 1.2). These structures will be discussed in next section.

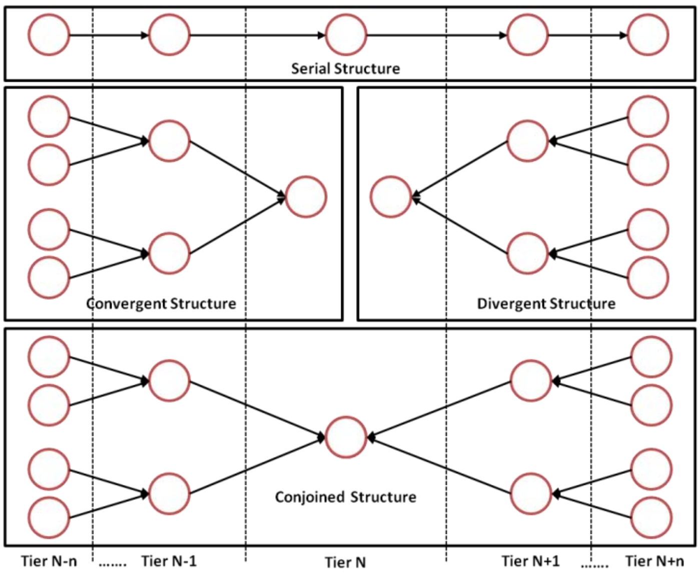

Figure 1.2. Structures of supply chains

1.1.2.1 Traditional structure

➢ *Serial structure*

A serial structure is a linear structure in which each supply chain node has only one successor and one predecessor. If raw materials are just changed in their sizes and shapes, but not assembled, a serial structure is obtained (Stadlter and Kilger, 2008). A typical serial supply chain studied in the literature consists of retailers, distributors, manufacturers and suppliers (Lau, 2007).

➢ *Convergent structure*

Convergent structures are assembly-type structures, in which each node (or facility) in the chain has at most one successor, but may have any number of predecessors (Beamon and Chen, 2001). It is a modification of serial supply chains, which basically represents a manufacturing supply chain in which several components and material provided by suppliers are assembled by a manufacture. The configuration of the convergent structure, like number of tiers, parts and number of suppliers and manufacturers in each tier, depends on the BOM (Bill Of Materials) of the end product (Lau, 2007). Examples of supply chains in convergent structures are some types of shipbuilding, aircraft manufacturing, automotive, building construction etc.

➢ *Divergent structure*

A supply chain may be classified as divergent if each node has at most one predecessor, but any number of successors (Beamon and Chen, 2001). It is another modified structure of the serial one. It is used to represent a more realistic distribution supply chain, in which one supplier (e.g. manufacturer) distributes stock to several downstream entities (e.g. retailer, distributor) (Lau, 2007). Among others, most types of mineral processing, chemical industry, petroleum oil, papermaking organizations are structured as divergent.

➢ *Conjoined structure*

A conjoined structure is a combination of convergent and divergent structure, where each comprised sub-structure (convergent and divergent) is combined in sequence to form a single, connected structure (Beamon and Chen, 2001). An assembly-type (convergent) structure in the procurement/assembly functions is often followed by a distribution-type (divergent) structure in the distribution part. Conjoined supply chain structures are common in farming, merchandise catalog, pharmacy and more generally in complex products manufacturing and distribution.

1.1.2.2 Supply network

A supply network does not fall into any of the preceding traditional structures. It is a general structure that is neither strictly convergent, divergent, nor conjoined. The structure of a supply network is much more complex and can be considered as a multi-directional network. It leads to unclear level or tier boundary, even loops, instead of bi-directional structure of a classical supply chain.

For most manufacturers, the supply chain looks less like a pipeline or chain than like an uprooted tree, where the branches and roots are extensive networks of customer and supplier

(Cooper et al., 1997), as Figure 1.3 shows. A single organization or facility typically procures materials from numerous suppliers (divergent), even within the otherwise convergent portion of the chain (Beamon and Chen, 2001). One supplier can possibly serve multiple tiers members with different requirements of different products.

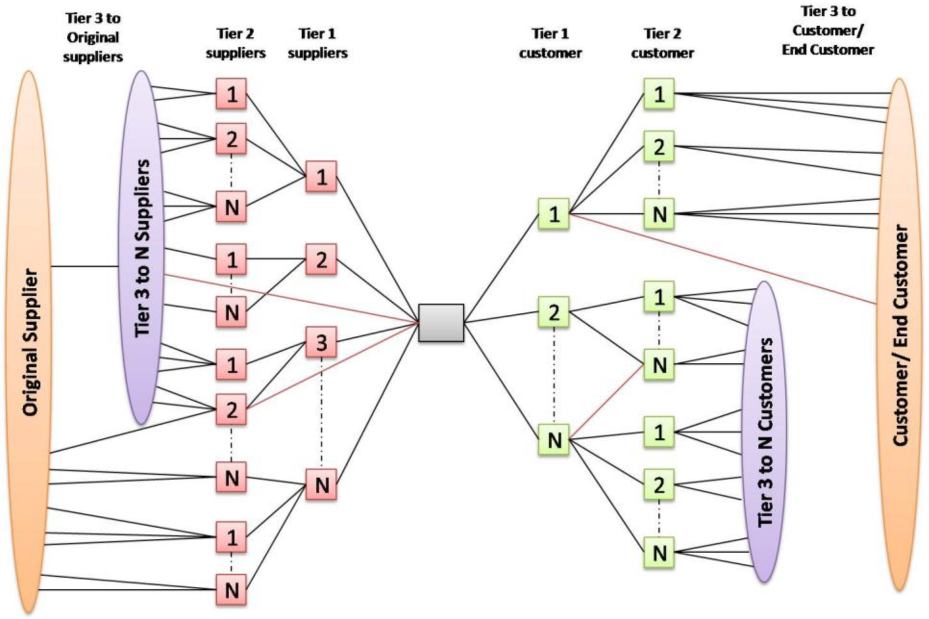

Figure 1.3. Supply Network Structure (Lambert et al., 1998)

1.2 Specificities of aircraft supply chains

Aircraft manufacturing is a typical global industry (with partners, subcontractors, and suppliers all over the world) characterized by high capital investment and R&D costs, long development and production cycles (it may take up to 5-6 years from release to delivery) (Klepper, 1990). Aircraft manufacturers are obliged to deal with high technological, financial, and market barriers. In order to reduce these barriers, a complex network of relationships has been developed over time. In order to better understand the specificities of the aircraft supply chains, it is firstly necessary to be aware of the real structure of the aircraft supply networks.

1.2.1 Global structure of aircraft supply networks

The aeronautical industry has an oligopolistic market structure characterized by high technological, financial and market entry barriers (Tyson, 1992; EEC, 1991). To lower these barriers, the aircraft firms implement a production organization characterized by a pyramid-shaped hierarchic structure (convergent network) including an assembly area where the parts and components coming from three sub-sectors (engines, equipment and avionics, and airframe) (Esposito and Passaro, 2009) and three different production levels (Esposito et al, 1996).

At the first level of the production pyramid is a leading firm (Airbus, Boeing...) carrying out aircraft assembly and responsible for the whole aircraft program (Esposito and Passaro, 1997). The three sub-sectors (engines, equipment and avionics, and airframe) have their own structure and a degree of autonomy, but are connected to the details of the program. The leader firm, which directly operates in the airframe sub-sector, organizes the flow of parts, components, systems and information and coordinates the program and assembly of the final product (Esposito and Passaro, 2009). Furthermore the leader firm has direct or indirect control of the whole production process, stores all the information relative to the product in order to be able to trace back the history of components, manages relations with the airlines, and is legally responsible for the aircraft (Esposito and Passaro, 2009).

The firms of the second production level manufacture complex parts and components of the aircraft both for the sub-systems manufacturers and for the assembler (fuselage, wings, motors, land gears etc.). Generally, these large firms are leaders in their own program, so that they belong both at the first and second level. These firms manage a very complex network of relationships. They are at the core of the vertical flows system of material and information that characterizes the production pyramid (Esposito and Passaro, 1997). They receive information on parts and components to be produced from the leading firm (Airbus, Boeing), then decide what they will produce in-house and what will be outsourced to third level suppliers. They also choose the third level suppliers (always considering the specifications and the minimum requirements of the leader firm) and follow and assist them in their growth process. The second level firms deliver to the leader firm all the parts and components realized (including the defectives ones) and the related information on their production process. They are also obliged to store a record of all the parts and components realized and the related information in order to give the leader firm the chance to verify in a very short time that they respect the conditions of the contract and the accuracy of the production process (Esposito and Passaro, 2009).

The third production level consists of Small and Medium Enterprises (SME), subcontracting firms who generally work for the second production level. From the second level firms, they receive the information on the production process, the manufacturing specifications, the technical service etc. When the manufacturing process is over, they transfer the ordered components and relevant information to the second-level customers. Suppliers in this level are also controlled by the leader firm that directly checks if they are able to meet the quality standards required and if the production process is realized according to the procedures imposed in the program. In the last few years, suppliers have become increasingly involved for sharing the risks of the programs and in the production of parts with high added value, including the management of their upstream suppliers (Esposito and Passaro, 2009).

Generally speaking, the production system of the aircraft industry has an international scale and involves: (a) the companies belonging to the world oligopoly (Boeing in US, Airbus in Europe); (b) large national firms (Alenia/Italy, Bombardier/Canada, Dornier/Germany, Saab/Sweden, Embraer/Brasil, etc.) with specific sectorial know-how; (c) and SMEs operating in a multi-tier suppliers system (Esposito and Passaro, 2009), see Figure 1.4.

1.2.2 Specificities

The production of the aircraft industry is characterized by managing and manufacturing wide range and number of components, normally over 1 million parts, components, semi-finished items, sub-systems etc. for one aircraft. A major difference with the automotive industry is the much higher diversity of the parts, since aircrafts are produced in much lower series, but contain much more different parts. These components have different and often very long lead times. The aircraft manufacturer is embedded in a network of subcontractors who supplies the parts of the aircraft. Most importantly, the engines, amounting to 20-30% of the value of an aircraft (Klepper, 1990), are developed by outside companies. Avionics, systems, and components (brakes, tires etc.) are often subcontracted as well. Some production stages are not specific to a particular type of aircraft, which makes the production planning complex. Some partners, sub-contractors and suppliers may be involved not only in aircraft supply networks, but also with other industries.

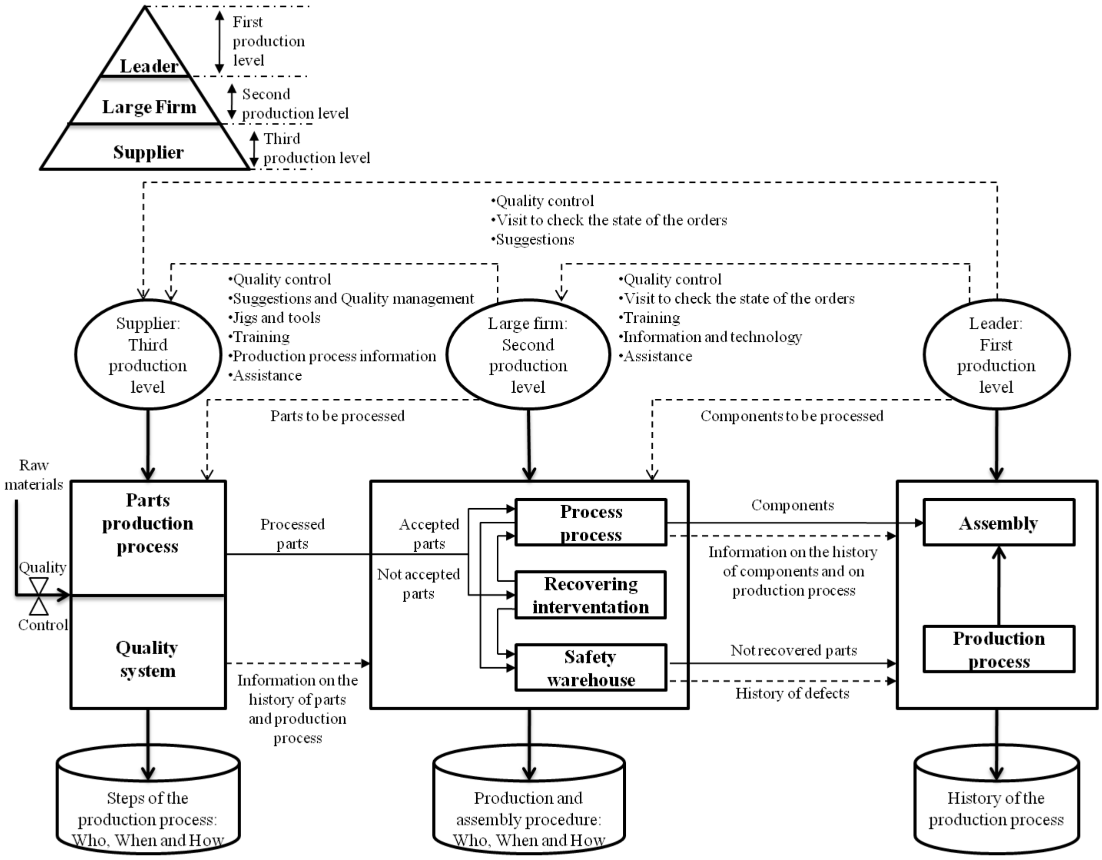

Figure 1.4. Aircraft manufacturing industry (Esposito and Passaro, 2009)

Based on these characteristics, the general constraints are to plan the production including a large number of parts for different types of aircrafts and to make sure these parts are delivered in the required moment and in the satisfying quality. In order to achieve such constraints, three important aspects can be emphasized:

- *Long term planning*

Since the aircraft production cycle is much longer than for other products, it requires the involved partners (subcontractor, supplier) to have a long term and well planned procurement, manufacturing, transportation etc., as well as to monitor the changes during a long period.

- *High flexibility production*

Manufacturing an aircraft is not a mass production process; every component is possibly different depending on the type of aircraft. This requires a high flexibility of each supply network member considering their production processes.

➢ *Efficient relationship*

As an industry dealing with many diverse parts, inventories are to be kept at the minimum level while ensuring a good availability of each component, since shortage may have tremendous consequences. Thereby, the storage and delivery of raw material, components, semi-finished products, and sub-systems should be exactly as required, which highly depends on the efficiency of the relationship between supply network members.

1.2.3 Specificities of the SMEs

In the aircraft industry, many small and medium-sized (SME) firms are involved at different production levels. These SMEs are very important in the entire supply chain. Therefore, it is interesting to compare the differences between Large Enterprises (LEs) and SMEs and clarify the SMEs' specificities.

Welsh and White (1996) succinctly summed and suggest that differences exist in structure, policy making procedures, and utilizations of resources to the extent that the application of large business concepts directly to small businesses may border on the ridiculous. In LEs, there are several layers of management between the manager at the strategic apex and operatives, resulting in the creation of a hierarchy of authority. This means that top managers, in large organizations, are far from the points of delivery. Thus, they are fully aware of the customer's needs, of strategic constraints and on the evolution of the competitive environment, but may be more far from operational issues (Ghobadian and Gallear, 1996). The operational processes and daily relationship with the suppliers is devoted to lower decisional levels, which receive their decision frames from the higher level decision makers. Therefore, these operational decision makers have to cope at the same time with the constraints coming from the upper decisional levels, mainly aiming at improving the efficiency of the supply network, and with the operational constraints coming from their suppliers, mainly linked to technical issues.

Compared with LEs, SMEs have traditionally been modeled with characteristics including having few products, few customer and low volume, lacking economies of experience and learning capacity, being bounded rational, having higher capital and transaction costs, having a reactive nature, being technologically focused with weak marketing skills, having limited resources and high strategic reliance on CEO perceptions of market forces and generally being more vulnerable (Coviello and McAuley, 1999; O'Gorman, 2001). To the difference with large companies, SMEs often rely heavily on a low number of very polyvalent persons. Therefore, the distinction between the roles and decisional levels is much lower than for large companies. SMEs' funds are weak, they have usually very important technical skills on their specialty but a lower maturity on information technology. Some of the traditional approaches and methodologies promoted by large companies (lean manufacturing, MRP...) are considered by some authors as not suitable for SMEs because they prefer logical reasoning approaches over systematic planning approaches, like aggregate production plans, production forecast, etc. (Thakkar et al., 2008).

In aeronautical supply chains, the difference between LEs and SMEs is emphasized due to the huge gap between the companies in terms of size, type of product, decision-making policy, production management tools etc. In SMEs, the planning process is not formal and multi-functional planning takes place within individual minds. Managers and operatives are more likely to be directly involved with the customers. Two way and face to face communication is the norm in SMEs (Ghobadian and Gallear, 1996). On the other hand, SMEs are more likely to be "people oriented" rather than "system oriented", and flexible. In fact, research shows (see (Appiah-Adu and Signh, 1998; Qualye, 2003)) that SMEs are more responsive to market needs, more adaptable to change, and more innovative in their ability to meet the customers' demand, but less oriented on information technology and management tools allowing long/middle term visibility.

2 Supply Chain Management

The first section of this chapter has tried to provide a general view of supply chains and to specify the common existing structures. Additionally, from the description of the specificities of aircraft supply chains, as well as from the particular specification of SMEs' characteristics involved in the industry, it is clear that management issues in such context require substantial efforts. Therefore, we are going to focus on supply chain management in the following section.

2.1 Concept of supply chain management

The traditional definition of supply chain management (SCM) as developed and used by the Global Supply Chain Forum (GSCF) is as follows:

> *"Supply chain management is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders."*

This broad understanding of SCM concept depicts a simplified supply chain network structure, information and product flow, and the key supply chain business processes penetrating functional silos within the company, so that the various corporate silos across the supply chain. Thus, business processes become supply chain business processes linked across intra- and intercompany boundaries (Lambert and Cooper, 2000).

There are also plenty of other definitions of SCM in the literature, coming from different points of view. For some authors for instance, managing a supply chain requires each member to have a chain-oriented attitude and at the same time to perform a specific set of collective actions and functions across the entire supply chain (Min and Mentzer, 2004). Thereby, Mentzer et al. (2001) define supply chain management as:

> *"SCM is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."*

To be more operational, various implemental issues are emphasized to maintain a chain-oriented attitude and manage a supply chain as a whole. Bowersox and Closs (1996) suggest that supply chain members should expand their integrated behavior to customers and suppliers, for instance through integration of processes from sourcing to manufacturing and to distribution across the supply chain.

Related to this integrated behavior, mutual sharing of information during planning and operational processes is another emphasis addressed by Cooper et al., (1997) or Tyndall et al., (1998). These authors suggest that frequent information updating and sharing at different levels (Cooper et al., 1997), such as inventory level, forecasts, sales promotion strategies, marketing strategies etc. reduce the uncertainty between supply partner (Yu et al., 2001) and result in enhanced performance (Andel, 1997; Salcedo and Grackin, 2000).

Besides, it requires partners to build and maintain long-term relationships to perform successful SCM (Cooper et al. 1997; Tyndall et al. 1998; Lambert et al., 2004). Cooper et al. (1997) believe that the time horizon of relationship extends beyond the life of the contract, perhaps indefinitely, and consequently long term relationships are more efficient and effective than shorter ones (Lambert et al., 2004).

2.2 Supply chain management processes

The definitions of supply chain management lead to the notion of process. Successful supply chain management requires a change from managing individual functions to integrating activities and then to key supply chain business processes (Lambert et al., 1998). Therefore, many works suggest reference models for the processes of the supply chains. In this section, we choose to introduce some popular and widely recognized works.

2.2.1 GSCF frameworks

The GSCF (Global Supply Chain Forum) has suggested a framework for understanding Supply Chain Management based on the works of Cooper et al. (1997). This framework consists of eight key business processes that are both cross-functional and cross-firm in nature. Each supply chain management process has both strategic and operational sub-processes. The strategic sub-processes provide the structure for how the process will be implemented while the operational sub-processes provide the detailed steps for implementation. The initial detailed processes are:

- *Customer relationship management*
- *Customer service management*
- *Demand management*
- *Order fulfillment*
- *Manufacturing flow management*
- *Procurement*
- *Product development and commercialization*
- *Return*

There are a lot of different terms used by authors considering the same or similar processes. The latest version of GSCF framework is presented by Lambert (2008), as Figure 1.5 shows. Lambert states that the value of having standard business processes in place is that managers from organizations across the supply chain can use a common language and can link-up their firms' processes with other members of the supply chain, as appropriate.

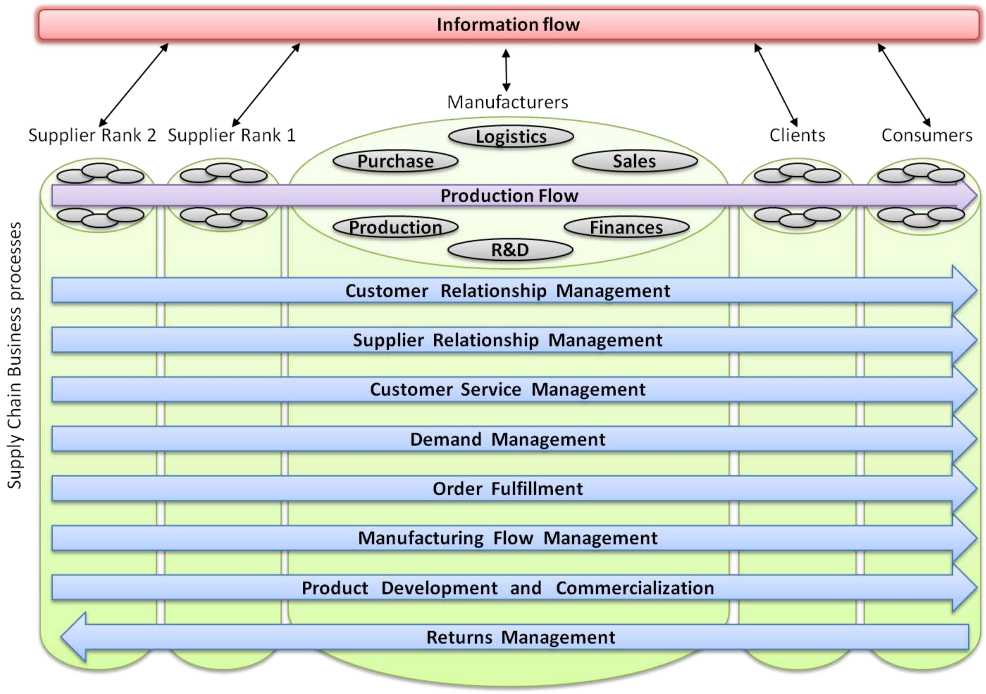

Figure 1.5. Integrating and managing business processes across SC (Lambert, 2008).

2.2.2 SCOR

The Supply Chain Operations Reference Model (SCOR), developed by the Supply-Chain Council (SCC), provides an operations reference model that links business processes, metrics, best practices and technology into a unified structure (SCOR, 2008) (see Figure 1.6). The SCOR model has been developed to describe the business activities associated with all phases of satisfying a customer's demand. SCOR allows companies to communicate using common terminology and standard descriptions of the process elements that help understand the overall supply chain management process and the best practices that yield the optimal overall performance (Huang et al., 2005). It provides a decomposition of five generic processes from the suppliers' suppliers to the customers' customers, all aligned with the company's operational strategy, material, work, and information flows. In addition, an "enable" process element is added to the model in order to prepare, maintain, and manage information or relationships on which the other processes rely.

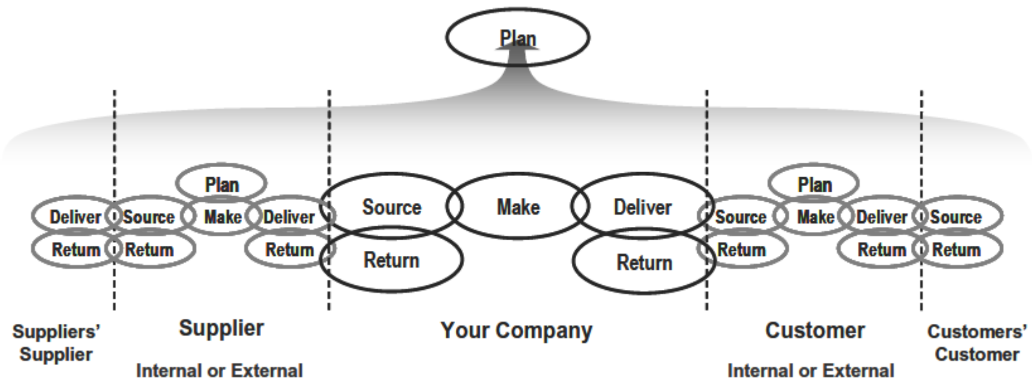

Figure 1.6. SCOR five major management processes

The five processes are the followings:

- *Plan*
- *Source*
- *Make*
- *Deliver*
- *Return*

2.2.3 Supply chain operation model

Another model for supply chain operations is suggested by Gilmour (1999) focusing on the logistics operation of the involved companies. This strategic model describes both a framework, which can be used to evaluate supply chain processes, and a group of benchmark measures, which can be applied to supply chain processes. The measures are based on a set of capabilities, which incorporate the extent of integration, and the use of technology in the logistics processes of an organization. It consists of six functional process capabilities (A):

- *Customer driven supply chain (A1)*
- *Efficient distribution (A2)*
- *Demand-driven sales planning (A3)*
- *Lean manufacturing (A4)*
- *Supplier partnering (A5)*
- *Integrated supply chain management (A6)*

These processes are supported by enabling capabilities in information technology (B) and organizational characteristics (C), see Figure 1.7.

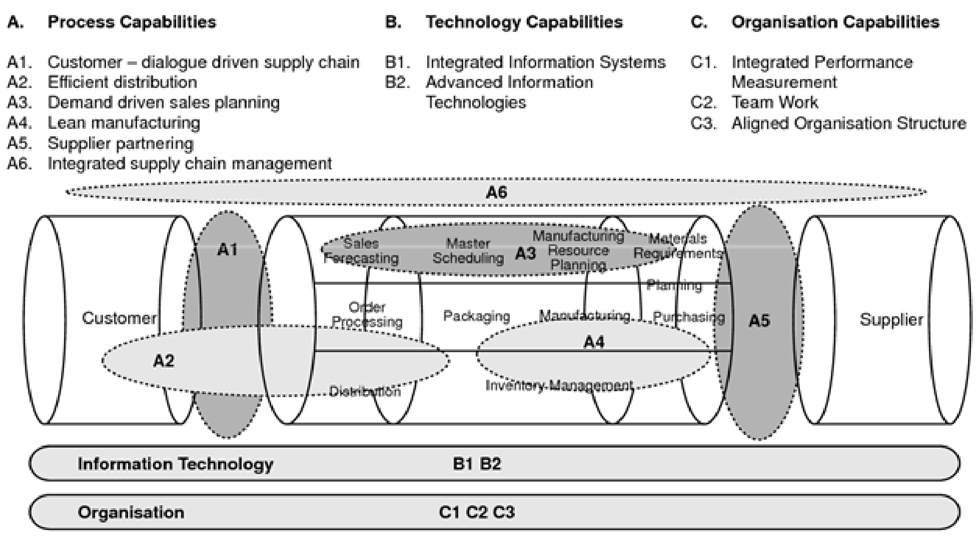

Figure 1.7. The integrated supply chain model (Gilmour, 1999)

2.2.4 ASLOG

The ASLOG (Association française pour la LOGistique) Audit is a reference method provided by the French ASLOG association, which aims to improve the performance of overall enterprise supply chain logistics (ASLOG, 2006). The ASLOG Audit is a kind of quality audit approach oriented on key processes of supply chain logistics, and on the development of continuous improvement plans. The ten supply chain processes suggested by ASLOG Audit are:

- *Management, strategies and planning*
- *Design*
- *Sourcing*
- *Production*
- *Transportation*
- *Stock*
- *Sales*
- *Return and maintenance*
- *Management of indicators*
- *Permanent progress*

2.2.5 GLOBAL EVALOG

GLOBAL EVALOG is the combination of EVALOG (Guide d'EVAluation LOGistique) from global GALIA Odette and MMOG (Materials Management Operations Guideline) from AIAG (Automotive Industry Action Group). It allows self-assessment or audit of supply chain partners in the form of a questionnaire and calculating a score in the automotive industry (EVALOG, 2006). EVALOG focus on four processes (Gruat la Forme, 2007):

- *Customer relationship*
- *Supplier relationship*
- *Manufacturing*
- *Product development*

These various frameworks have been compared by Gruat La Forme, (2007) and Estampe et al., (2011), showing their characteristics and consistence. In practice, SCOR appears to be the most widely used, mainly because of the large influence of the Supply Chain Council. It is firmly rooted in industrial practices and is poised to become an industrial standard. It is interesting to notice that the management of the supply chain through SCOR is performed using a "point-to-point" logic by connecting the "source" process of one company to the "deliver" process of his upstream partners.

Despite of supply chain management processes, different type of decisions play important roles in synchronizing local processes and global ones, and ensuring the smooth workflow of supply chain management. Therefore, we are going to introduce supply chain management decisions in the following section.

2.3 Supply chain management decision

2.3.1 Decision levels

SCM requires making decisions at various levels of a firm's activities (Mahmood et al., 2003): strategic, tactical, and operational which have been defined as early as 1965 (Anthony, 1965). These three planning levels differ in their level of aggregation and planning horizon (Chopra and Meindl, 2004).

- *Strategic level*

Strategic decisions are the longest horizon activities (one year or more) allowing the firm to meet its defined objectives and assuring that it has the proper resources and assets necessary to support its long term objectives (Miller, 2001). The SC strategy has to be specific in considering a given SC's potentials and will guide the specific design of building blocks best serving a SC's needs (Stadtler and Kilger, 2007). To be precise, these decisions pertain to how to structure the supply chain (Lamothe et al., 2004) including the number, location, and capacities of manufacturing and warehousing facilities; types of products to be manufactured and stored at the various facilities; and the modes of transportation of materials through the logistic network, as well as the type of information system to be used (Mahmood et al., 2003).

- *Tactical level*

Tactical decisions include the medium planning (one to six months or more) focusing on resource allocation and resource utilization (Anthony, 1965). At the tactical level, the focus is on how to most effectively utilize the infrastructure and capacity that the implementation of strategic decisions has created (Miller, 2001). These decisions relate to defining operating policies that govern short-term operations. These policies may be updated anywhere between once quarterly and once yearly, and would pertain to such decisions as, among others, purchasing and inventory replenishment policies, which markets to be supplied from which locations, aggregate production volumes by product category at each manufacturing plant, and the planned buildup of inventories (Mahmood et al., 2003).

- *Operational level*

Operational decisions are day-to-day or weekly activities related to planning, scheduling and execution that assure that the organization performs individual tasks efficiently and effectively, supporting the higher level tactical plans (Anthony, 1965). At the operational level, the firm executes its daily decisions of operations using the resources made available by the tactical planning process (Miller, 2001). According to (Mahmood et al., 2003), these decisions are made with respect to placing replenishment orders, scheduling production, allocating product to individual customer orders, specifying the shipping date, and packing and loading each order, among many others.

2.3.2 Decision making policy

Supply chain is considered as an overall system, thereby supply chain management requires a high level of consistency between information flow and decision making processes. Since supply chains involve multiple members who have local objectives and global responsibilities, the policy of decision making considering the local decision making, supply chain global decision making and the relationship between these two has important effects towards supply chain management.

Trentesaux (2002) suggests four classes of arrangement of the decisions: the Class 0 (centralized form), Class 1 (proper hierarchical form), Class 2 (modified hierarchical form) and Class 3 (heterarchical form), see Figure 1.8.

Class 0 is defined as a centralized structure in which there is only one decision center that concentrates all the information and makes all decisions.

Class 1 defines a hierarchical system. At each level, there are local decision centers that are connected with the higher level ones. It is characterized by a rigid structure in which the higher level centers define constraints, goals etc. and transfer these down to lower levels. Decision-making process is realized by means of unidirectional decisions that are passed in a structure looking like a decision tree.

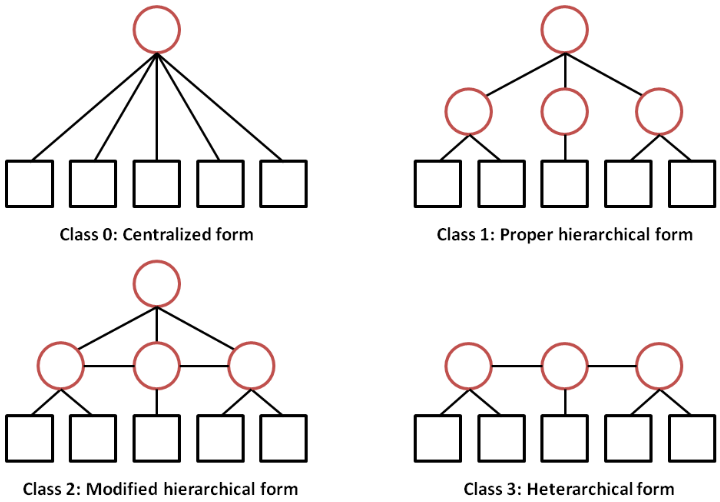

Figure 1.8. Classes of decisional arrangement (Trentesaux, 2002)

Class 2 defines an integrated system. Compared to the hierarchical architecture, this architecture offers an opportunity for coordination of the decisions on the hierarchical level. The decision-makers on the same level can exchange information, giving rise to coordination.

Class 3 defines a pure distributed system. It constitutes a heterarchy in which decisions are no longer subordinated by decisions hierarchically superior. This structure is a decentralized form that also offers coordination of decision-making on each level.

According to Pujo and Kieffer (2002), hierarchical form could be considered as an extension of the first class, centralized form (class 0). Similarly, in the thesis of R. Affonso (2008), it is suggested that the modified hierarchical form (also named as coordinate structure, class 2) could be decomposed into proper hierarchical form (class 1) and heterarchical form (also named decentralized structure, class 3). Thus, centralized and decentralized forms (heterarchical form) are the most basic structures of decision making. In the context of supply chain management, these two structures are the most widely adopted for implementing the decision making policy.

We shall now see how these frameworks can be applied to the case of supply chain management.

➢ *Centralized decision making in SCM*

Centralized decision making assumes that the supply chain is managed by a single decision maker (company) which has access to all the information and makes system optimal decisions (Whang, 1995; Fugate et al., 2006) (see Figure 1.9). It aims to support corporate planning and purchasing, optimize system performance and better meet the global objective of the supply chain (Sahin and Powell, 2005).

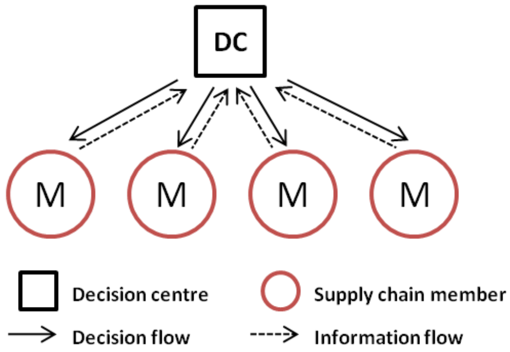

Figure 1.9. Centralized decision making in supply chain (Pujo and Kieffer, 2002)

Centralized decision making policy focuses on determining the global plans in one single decision center and then decomposes them towards each supply chain member. Such policy is mainly implemented for managing a set of workshops or distributors belonging to the same company, in which case transaction data are easily collected and integrated. Furthermore, centralized decision making requires supply chain members to share multiple levels of internal data and keeps a poor level of business autonomy. This can hardly be accepted by independent companies, especially when they are involved in multiple supply chains or supply networks.

- *Decentralized decision making*

Decentralized decision making differs from centralized one in that supply chain members act independently to optimize their individual performance. Meeting common objectives requires in addition a cooperative effort among the supply chain members, who have limited shared information but work together, communicate and coordinate their activities to achieve system optimization (Whang, 1995). Each supply chain member keeps his individual decision center for managing his plans and operational processes. Along the entire chain, it requires to communicate and share some information among the members, as summarized in Figure 1.10.

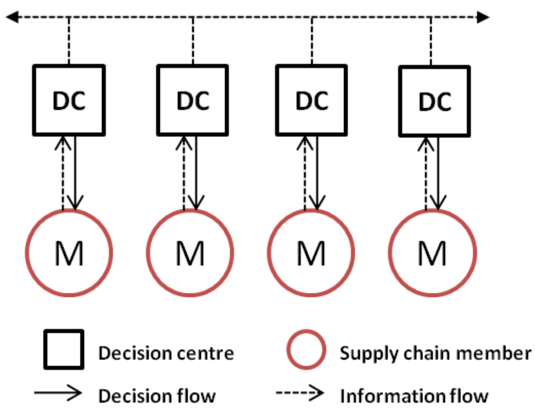

Figure 1.10. Decentralized decision-making in supply chain (Pujo and Kieffer, 2002)

Decentralized decision making is widely adopted by supply chain partners aiming at keeping business autonomy and confidential data. However, it requires sharing information in multiple levels to synchronize the local decision making, and accordingly, optimize the performance of the entire supply chain. Therefore, the key points of decentralized decision are communication, level of information sharing, and adjustment of local decision making according to global perspectives. Since supply chain members are individual entities pursuing maximum benefits, their attitude for balancing local benefits and global perspectives is the crucial issue to perform the decentralized decision making policy.

2.4 Tools and methods for supply chain management

As mentioned, supply chain management deals with two main interrelated issues: product flow and information flow. The main purpose is to ensure that each supply chain member contributes and adds value to transforming raw material into finished product towards the customer through coordinating local product flow and related information in parallel. For instance, determining the manufacturing orders (MO) according to the sales orders forecast and inventory level, furthermore generating the purchase orders (PO) for the suppliers are the routine activities of manufacturers in a supply chain. These are not easy tasks, especially when aiming at satisfying deliveries (at the right time, with the right quantity and quality, to the right places) with the imperative of lower costs. Thereby, tools, methods and software for supply chain management are widely suggested in the literature and in the industry. We choose to introduce four of them, APS, MRP/ERP, JIT/LEAN and TOC in this section, which are the most commonly used tools or methods in supply chain management.

2.4.1 APS

An APS (Advanced Planning System) is a software allowing decision making on supply chain design then planning and scheduling, for industries federated and synchronized between different divisions, within or between enterprises, to achieve total and autonomous optimization (Nishioka, 2005). An APS includes a range of capabilities, from finite-capacity scheduling at the shop floor level through to constraint-based planning (Turbide, 1998). It necessitates deciding when to build each order, in what operation sequence, and with what resources to meet the required due dates (Lee et al., 2002). Standard APS modules stem from the many in-house developed Decision Support Systems (DSS) that aid planners at various levels in the decision hierarchy (de Kok and Graves, 2003).

APS are widely used to assist the tactical supply chain planning in centralized supply chains. APS can give supply chain decision makers the information on demand forecast and decision support capability they need, since APS tools are designed to help companies to balance plans and schedules, most of the time based on constraint propagation. An APS is also capable to monitor very detailed data about the status and constraints of each supply chain member and to broadcast such information to the entire supply chain through optimized planning (Lendermann et al., 2001). Nevertheless, it is clear that the use of an APS, requiring centralized supply chain management, is not adapted to our context where the problem is to coordinate autonomous/independent entities of the aeronautic sector.

2.4.2 MRPII/ERP

The MRPII (Manufacturing Resource Planning) method (Orlicky and Plossl, 1994) is an extension of MRP (Material Requirement Planning), both at higher and lower decisional levels. Its aim is to progressively build a feasible production planning, taking into account not only the availability of materials but also the capacity of the resources, then to monitor the execution of this plan. In that purpose, the MRPII method uses the principles of hierarchical production planning (see right part of Figure 1.11), i.e. it checks for the feasibility of a progressively refined production planning at different time horizons, the accuracy of the plan increasing while the period of times decreases. In that way, it is possible to cope with the uncertainty of the demand (since the higher level plan only deals with families of products for which the demand is more predictable than for precise products) and to control the complexity of the plan (since the amount of data to take into account remains rather constant for each level).

Figure 1.11 shows an example of a point-to-point supply chain management (one simple case of decentralized management) using a cascade of MRPII modules. The Sales and Operations Planning (S&OP) (Wallace, 2004), first step of MRPII, is a cross-functional communication and decision making process aiming at balancing demand and supply at the volume level. At the S&OP level, it is paid more attention to the bottlenecks and critical resources with a long time horizon (months or trimester). The S&OP connects the business planning and the lower level planning, namely the Master Production Scheduling (MPS), through balancing the demand and rough cut capacity. Down to the next level of planning, the S&OP combined with firm orders and forecast from both known customer and new ones is translated into a realizable production plan. At the MPS level, planning is not anymore on product families but on finished product, with shorter time horizon (months or weeks) ; rough cut capacity is adjusted from factory/workshop into more precise balancing within production lines or cells. Afterwards, the Material Requirement Planning (MRP) is generated, fed by the MPS located at the upper level. At the MRP level are generated requirements on materials based on the requirements on finished products created at the upper level, using the Bills of Material (BOM), taking into account lot sizing constraints. The MRP level generates both suggested production orders and suggested replenishment orders: based on the latter, the upstream supply chain members receive orders/forecast/supply programs generated from the MRP plan of their downstream partners. The final steps of the MRPII method concern the operational decisions aiming at managing the internal production resources: Load planning, where a precise load/capacity balance is performed, and Scheduling, where operations are sequenced before being released.

The MRPII method requires dedicated information processing capabilities, provided in the past by dedicated production management tools. Nowadays, these tools are most often included in ERP systems.

An ERP (Enterprise Resource Planning) is a comprehensive industrial software focusing on the integration of traditional functions, such as human resources, finance, sales, production, in business processes (Kelle and Akbulut, 2005). Built on a centralized database and normally utilizing a common computing platform, ERP systems consolidate all business operations into a uniform and enterprise wide environment. As such, they include the MRPII but also additional tools aiming for instance at selecting or assessing suppliers, communicating with the customers, etc. An ERP system could potentially enhance the data collection and transparency of each member across the supply chain, by eliminating information distortions and increase information velocity by reducing information delays. Hence, there are reasons to believe that ERP adoption could be associated with significant gains in supply chain effectiveness (Akkermans et al., 2003).

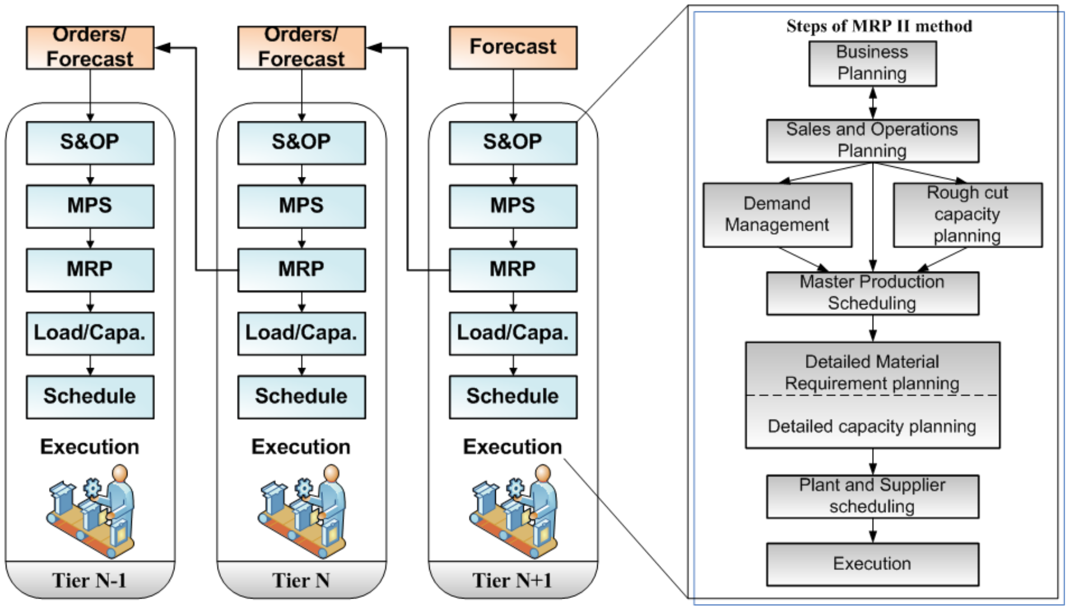

Figure 1.11. A point-to-point supply chain planning using MRPII method (Marcotte, 2009)

In a decentralized supply chain, a cascade of ERP systems is considered as a mean to exchange information with partners, due to its advantage of local information integration. Since production data is clearly visualized and well formatted in ERP system, supply chain members have better pictures of information to exchange or to keep. MRPII (Manufacturing Resource Planning), the core production model of an ERP system, is usually used to perform and organize planning during cooperation processes, including sharing information in different levels of operation plans and purchase orders. On the other hand, a difficulty is of course the global optimization of the supply chain performance.

2.4.3 LEAN/JIT

Lean Manufacturing (Warnecke and Hüser, 1995) is a generic philosophy derived mostly from the TPS (Toyota Production System), consisting mainly in waste elimination and process streamlining techniques. One of the mottos of Lean is to only do "what is needed, when it's needed, in exactly the right quantities, with a minimum amount of resources". Lean production is supposed to use half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time if compared to previous methods. Also, it requires keeping far less than half the needed inventory on site, results in fewer defects, and produces a greater and ever growing variety of products (Womack et al., 1990). There is a strong emphasis in Lean Production on reducing the use of all resources, not only in the factory, but also in activities extending beyond the shop floor such as product development and supplier relations (Bruun and Mefford, 2004). The primary goal of Lean Production (Lamming, 1996) is to re-range the work flow and generate flexibility in order to achieve zero waste, such as, the lead time of purchasing, working in progress, storing cost in inventory.

Lean is achieved through a set of mutually reinforcing practices, including just-in-time (JIT) (Crawford and Cox, 1990; Monden, 1993), total quality management (TQM), total productive maintenance (TPM), continuous improvement, design for manufacturing and assembly (DFMA), supplier management, and effective human resource management (de

Treville and Antonakis, 2006; Narasimhan et al., 2006; Shah and Ward, 2003, 2007). Among these, JIT is a principle that is closely associated with lean manufacturing. According to Monden (1998) and Levy (1997), JIT is the backbone of lean manufacturing, which is considered as a system where a customer initiates demand and the demand is then transmitted backward from the final assembly all the way to raw material, thus "pulling" all requirements just when they are required (Monden, 1998; Feld, 2000; Nahmias, 2001).

JIT requires drastic conditions for being used, and especially a stable and mass production which is not really the case in the aeronautic sector. Manufacturing by small lots is one the key conditions for producing in JIT, but its full impact will only be obtained if raw materials are provided often, but in small quantities (in order to decrease raw material inventories) and if the customer also accepts to be delivered often and in small quantities (in order to decrease the finished products inventories). A full benefit of JIT requires so that this technique is adopted all along the supply chain: the effort of the large companies for having their suppliers close to their factories in the automotive sector illustrates it. Decreasing delivery costs and increasing reliability in deliveries require to have particular relationship with privileged suppliers. Real JIT is unusual for the aircraft industry, which is characterized by small series and quasi-craft production, high quality standards and a long time-to-market. Nevertheless, the principles of lean manufacturing are promoted by the large companies of the aeronautic sector as a key mean of improvement of the supply chain performance.

2.4.4 TOC

The Theory of Constraints (TOC) (Goldratt, 1990) is an extension of the OPT (Optimized Production Technology) method which has been suggested at the beginning of the 1980's by E. Goldratt (Goldratt and Cox, 1984; Goldratt and Fox; 1986, Goldratt; 1988). The base of the TOC method is the interpretation of the problem of load/capacity balance according to three operational indicators: the rate of sale or throughput, the inventory, and the operating expenses. TOC focus on bottlenecks (considered as manufacturing resources in OPT, then as constraints with different origins in TOC), and provides a total solution for managing a factory in order to optimize on time delivery, inventory and operating costs (Pérez, 1997).

Within a supply chain too, the global efficiency is determined by the bottleneck(s), i.e. the lowest productivity node(s). In a supply chain, TOC may help to specify the data elements (linked to the limiting constraint) that are necessary to manage the interaction among non-constrained and constrained partner to achieve supply chain goals (Pérez, 1997). The purpose of supply chain management is to deal with these supply chain constraints and bring the supply chain performance to a higher level. TOC suggests a five-step approach to deal with the system's constraints. By this mean, TOC supports a continuous improvement philosophy, which considers supply chain as an ongoing process (Kampstra et al., 2006).

The successful usage of TOC in supply chain cooperation requires to envisage the constrained node of supply chain and deeply dig its capabilities and potentials according to different requirements. It also needs to balance the constrained node and others in order to ensure the consistency of every stage of the supply chain. In case of movement of the constraining partner, the key points are re-targeting the new position of the limiting constraint and rebuild a balanced, efficient supply chain system. The application of TOC in supply chain cooperation is not an easy task and is even questioned by practitioners. One problem is that it requires a heavy real time monitoring of all the supply chain resources and individual processes, which is rather unrealistic. Other problems are also complicated, such as how to determine a constraining partner in a supply chain by balancing local perspective and global purpose. Whether the supply chain member is willing to contribute efforts to achieve the TOC goals, which is the responsibility of a committed supply chain partner, is also a question.

3 Cooperation in Supply Chain

Although supply chain management issues have been widely considered by both academics and practitioners on the technical point of view, this way to address the problem is not sufficient to deal with the new changes of market environment. In recent decades, intensive competition in the market place has forced companies to respond more quickly to customer needs through faster product development and shorter delivery time (Simatupang and Sridharan, 2002). Product customization without a corresponding increase in costs is the new frontier in business competition for both manufacturing and service industries. To survive in this competitive context, manufacturers are forced to maintain high level of efficiency, agility, flexibility and a clear vision of entire supply chains which requires to make quick responses to customer's requirement or changes and ensure a satisfying delivery. These capabilities are hardly achieved by a single supply chain member, but require developing an increased partnership allowing information sharing, joint planning and decision making, favorable customer-supplier relationship and other co-working activities across the entire supply chain. Therefore, the term "management" is growingly completed in the literature by terms like coordination, cooperation, collaboration, these terms becoming more and more popular in research papers of several fields (industrial engineering but also social sciences or management). Many authors, for instance Telle, (2003) and Parrod, (2005) focus on the development of relevant co-working activities through determining models, methods, tools etc. but few of them have been interested in making a clear distinction among these terms. In the following section, we shall try to distinguish these terms based on the existing literature and on our view of the co-working among supply chain members.

3.1 Concept of cooperation

3.1.1 Synthesis of different terms

All the mentioned terms, coordination, cooperation, and collaboration, represent various degrees of "working together" among supply chain members. However, the meaning attached to each word varies according to the different authors (see Table 1.1).

3.1.1.1 Coordination

- *Etymological analysis*

Coordination is defined as the problem of mastering the numerous degrees of freedom involved in a particular system for reducing the number of independent variable to be controlled (Bernstein, 1967). The coordination problem as defined by Singh (1989) refers to the integration and harmonious adjustment of individual work efforts toward the accomplishment of a larger goal.

Coordination is also managing dependencies among activities performed to achieve a goal from coordination theory (Malone and Crowston, 1990; Malone and Crowston, 1994; Malone et al., 1999; Castelfranchi, 1998; Raposo et al., 2001). Coordination is the act of working harmoniously in a concerted way; nevertheless, each entity might have a different goal and use its own resources and methods (Camarinha-Matos et al., 2009). It is necessary to find a decomposition of the goal into independent sub goals and corresponding networks without mutual impediments.

Table 1.1. Various terms on supply chain co-working

Terms	Contents	Author (Year)
Coordination	Supply Chain coordination is a vehicle for redesigning decision rights, workflow, and resources between chain members to leverage better performance.	Lee and Whang, 2000
	Coordination within a supply chain is a strategic response to the challenges that arise from these dependencies.	Xu and Beamon, 2006
	Coordination can be achieved when the supply chain members jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the production and replenishment processes are determined.	Hill and Omar, 2006
Cooperation	Cooperation refers to similar or complementary, coordinated activities performed by firms in a business relationship to produce superior mutual outcomes or singular outcomes that are mutually expected over time.	Anderson and Narus, 1990
	Cooperation is not limited to the needs of the current transaction and happens at several management levels (e.g., both top and operational managers), involving cross-functional coordination across the supply chain members.	Cooper et al., 1997
	Cooperation produces several benefits for the SC actors which have been identified as a list of possible advantages of the cooperative SC relationships including time and cost reduction, better product design, and improved quality.	Albino et al., 2007
Collaboration	A collaborative supply chain simply means that two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation.	Simatupang et al., 2002
	Collaborations in supply network mean long-term relationships among members through reductions in transaction costs, and increase in resource sharing, learning, and sharing of knowledge.	Cousins, 2002
	Collaboration provides an effective mechanism for the joint creation and promotion of new technical standards.	Bahinipati et al, 2009
Mixed Terms	Collaboration includes knowledge integration and cooperation between organizations, which are recognized as resources that might generate competitive advantage.	Grant, 1996
	Collaborative working for joint planning, joint product development, mutual exchange information and integrated information systems, cross coordination on several levels in the companies on the network, long term cooperation and fair sharing of risks and benefits.	Larsen, 2000

Besides, coordination involves aligning/altering activities so that more efficient results are achieved. The work which is coordinated involves more than one person, includes shared objectives, requires an understanding of personal roles and responsibilities, and is generally overseen by someone (e.g. coordinator). There is a general assumption that there may be overlaps in the work, even though different people/units come into the process working on specific pieces. Coordination of joint activities occurs as businesses become entwined in a real-time exchange of information on goals, tasks and resources in many areas, such as demand planning, distribution, transportation and manufacturing (Seifert, 2002).

➢ *Supply Chain contextual analysis*

In the context of a supply chain, authors hold various opinions. Simatupang et al., (2002) consider that coordination among independent supply chain members, such as raw-material suppliers, manufacturers, distributors, third-party logistics providers and retailers, is the key to attaining the flexibility necessary to enable them to progressively improve logistics processes in response to rapidly changing market conditions. Poor coordination among the chain members can cause dysfunctional operational performance. According to Simatupang et al., coordination in supply chain should deal with the entire processes and operational performance. In the same manner, Konijnendijk (1994) examined the coordination process at the tactical and operational levels in terms of product specification, volume, mix and lead-times between sales and manufacturing in engineer-to-order (ETO) companies. Stank et al. (1999) studied coordination processes characterized by effective communication, information exchange, partnering and performance monitoring in food industry supply chains.

Different from the above statements, Arshinder et al. (2007) suggest that supply chain coordination relate to an effective management of disparate but dependent members/processes, not only through coordinating different and complex processes of supply chain involving human system (as supply chain members), but also different difficulties and interests, like opportunistic behavior, disagreements over domain of decisions and actions, inappropriate performance measures, misalignment of performance measures with overall supply chain, traditional and outdated policies, failure to differentiate with whom to coordinate, lack of trust etc.

3.1.1.2 Cooperation

➢ *Etymological analysis*

Groves (1985) perceives cooperation as the association of a number of persons for their common benefit; as a collective action in the pursuit of common wellbeing, especially in industry or business. Cooperation requires division of labor among participants, meaning that each person is responsible for a portion of the problem solving. The task is split hierarchically into independent subtasks (Dillenbourg et al., 1996; Dillenbourg, 1999; Roschelle and Teasley, 1995). Cooperation is also considered as a structure of interaction designed to facilitate the accomplishment of a specific end product or goal through people working together in groups (Panitz, 1997). It suggests compliance in some manner, sharing something, all for mutual benefit, thereby, the motives and the actions in cooperation are parallel and mutual (Taylor, 1957).

Cooperation is a function of mutual dependence: in cooperation, in the strict sense, agents depend on one another to achieve the same goal. They are co-interested in the convergent result of the common activity (Castelfranchi, 1998). Minimum requirements for cooperation include partial goal agreement, joint usage of limited resources, coordination of individual actions and definitions of goals and conventions relevant to the joint tasks. Cooperation involves not only communication, information exchange, and adjustments of activities, but also resources sharing for achieving compatible goals (Camarinha-Matos et al., 2009).

➢ *Supply Chain contextual analysis*

In the context of supply chain, Albino et al. (2007) consider cooperation as suppliers and buyers becoming strategic partners, sharing risks and benefits, exchanging operating and financial information, making joint investments in facilities and systems, jointly involved in continuous improvement and new product development programs, and making their success interdependent. Such cooperation is based on a “strategic partnership” also called cooperative SC relationships (Scott and Westbrook, 1991; Ellram, 1991). In such business relationship (Anderson and Narus, 1990), cooperation starts with joint planning and ends with joint control activities to evaluate performance of the supply chain members as well as the supply chain as a whole (Ellram and Cooper, 1990; Cooper et al., 1997; Tyndall et al. 1998). Cooperation between organizations to manage logistical, financial, technical and design interdependencies means that a product market supply chain behaves as one unit - the competition between individual organizational units diminishes and is replaced by competition between supply chains (Holland, 1995).

3.1.1.3 Collaboration

➢ *Etymological analysis*

Collaboration is the most formal inter-organizational relationship involving shared authority and responsibility for planning, implementation, and evaluation of a joint effort (Hord, 1986). Collaboration is also a philosophy of interaction and personal lifestyle where individuals are responsible for their actions, including learning and respect the abilities and contributions of their peers (Panitz, 1997). Nokkentved (2000) views collaboration as negotiated cooperation between independent companies, by exchanging capabilities and constraints to improve collective responsiveness and profitability. He specifically defines inter-organizational collaboration as the process by which organizations exchange information, alter activities, share resources and enhance each others’ capacity for mutual benefit and common purpose by sharing risks, responsibilities and rewards. Collaboration is accomplished by involving the mutual engagement of participants in a coordinated effort to solve the problem together. Successful collaborative work requires a culture of collaboration, leadership, common vision, information support systems and teamwork. A collaboration process happens for instance in concurrent engineering, when a team of experts jointly develop a new product (Camarinha-Matos et al., 2009).

The goal of collaboration is not to establish a positive relationship between partnering groups, but the pursuit of a specific result. Collaboration relies on both cooperation and coordination of efforts, but goes far beyond these two working relationships. Collaboration is not about consensus building. A true collaborative effort creates something new with a collaborative brainstorm (e.g. a new philosophy, way of doing something, changes in overall personnel roles) and is ever evolving and dynamic in nature. Creating collaboration requires a hard work, and needs constant tending. It requires a great deal of time and communication.

➢ *Supply Chain contextual analysis*

For some authors, a collaborative supply chain simply means that two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation (Simatupang et al., 2002). For others, collaborations in supply networks mean long-term relationships among members (Lauras et al., 2003) through reductions in transaction costs, and increase in resource sharing, learning, and sharing of knowledge (Cousins, 2002). Collaboration is more than sharing information and horizontally integrating the operations of the network, since collaboration is largely a social process while information sharing is largely a technological process (Shore and Venkatachalam, 2003). In order to achieve collaboration in a supply chain, the manufacturer and the supplier exchange information and goals on demand plans, customer patterns, product design and development, as well as incorporating bulk buying discount and availability. Collaboration, which is most appropriate when issues or opportunities faced by supply chain partners are too difficult or complex to be resolved individually, requires joint planning and decision-making; open sharing of information; a free flow of creative ideas and rich communication through face-to-face meetings (Nix et al., 2004).

3.1.1.4 Synthesis

It can be seen from the previous statements of coordination, cooperation and collaboration in both etymological and supply chain context, that various (and sometimes inconsistent) definitions of these terms have been given in the literature. Often, supply chain academics and professionals use the words collaboration, coordination, and cooperation interchangeably. For instance, Arshinder et al. (2007) suggest that coordination in supply chain is not only to coordinate process, but also to coordinate the difficulties and interests, like opportunistic behavior, lack of trust etc, which are also considered as the element of cooperation. Similarly, some authors use the term “coordination” (Lee and Whang, 2000; Hill and Omar, 2006), however communicate on the concept of co-working, not only managing the interdependency of supply chain members, but also sharing resource/risks, joint planning, building a long term and efficient partnership, which seems to be closer to issues of cooperation. Lauras (2004) proposes to distinguish terms like coordination, cooperation, collaboration, partnership through their characteristics in data processing (exchange information, exchange processes and exchange both information and processes). Comparing with other authors, this distinction of different terms pays less attention to other critical elements, such as relationship, joint decision making, trust etc. Another work proposed by Camarinha-Matos and Afsarmanesh (2008) separates terms like networking, coordination, cooperation and collaboration based on their interaction maturity levels considering common goal-oriented risk taking, commitment, and resources that participants must invest into the joint endeavor.

Based on the original etymology of these terms, we have tried to clarify what characterizes these different situations. The primary difference between these terms is that coordination emphasizes the efficiency of local processes combined with clear definitions of assignments and roles of each member. Individuals or organizations that achieve coordination are interdependent and use their local resources and methods. More than coordination, cooperation and collaboration aim to pursue mutual benefits through sharing resource. The concept refers not only to efficiency but also to global responsibilities, joint planning and moreover relationship between co-working members. The cooperative attitude and motivation, mutual respect and trust, communication, and sharing information are crucial for both cooperation and collaboration; we shall investigate this point in further details in Chapter 5. In addition to cooperation, collaboration also stresses the collaborative brainstorm to new creation or innovation. Detailed different attributes of coordination, cooperation and collaboration are showed as Figure 1.12.

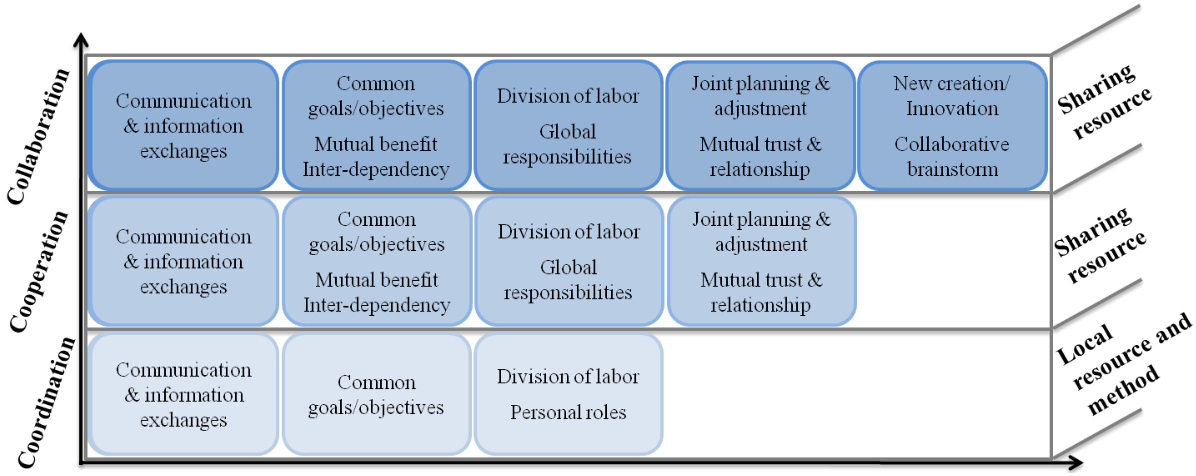

Figure 1.12. Attributes of different terms of working together

In nowadays context, organizations have recognized long term and better partnership as very important to develop powerful competitiveness. Therefore, cooperation with partners in supply chains means no longer only coordinating individual assignments nor behaving dependently. It requires a cooperative environment and global responsibilities through sharing resource, joint planning, mutual respect and trust, motivation etc. On the other hand, it is normally not obliged to create a collaborative brainstorm environment in order to maintain the satisfied performance of the global supply chain. Therefore, in the following sections, we choose to utilize term of "cooperation" to describe the activities and behaviors when supply chain members work together and pursue mutual benefits, furthermore maintain a high level of efficiency, agility and flexibility.

3.1.2 Objectives of supply chain cooperation

As mentioned, we propose to adopt the term "cooperation" which emphasizes the management of interdependent supply chain members who pursue common goals and mutual benefits. A cooperative environment is very important and has significant impact on supply chain members' behaviors, including sense of global responsibilities, mutual respect and trust, motivation and etc. In the context of supply chains, cooperation among supply chain members is an efficient way to maintain an agile and flexible network of procurement, manufacturing and distribution. Consequently, the involved members should be able to better visualize the entire functions of the supply chain or supply network and should be capable to make quick response and adjustment to the customer's requirements.

Thereby, the primary objective of supply chain cooperation is to ensure that the involved members perform their operational activities and cooperative behaviors coherently in order to achieve the common goals and mutual benefits. Secondly, since technical aspects are not sufficient for a cooperative performance, supply chain cooperation needs to establish a better customer-supplier relationship in which behavior issues (like trust, power, etc.) play important roles. Such customer-supplier relationship is an essential prerequisite for supply chain members working together coherently, furthermore being more agile and flexible as an alignment which could improve the satisfaction of customers.

3.2 Practical methods for supply chain cooperation

Since supply chain cooperation has gained substantial attention both in literature and practice, relevant methods for cooperation are growingly highlighted and successfully achieved by practitioners. In the following section, we will introduce some of these methods which are practically used in companies.

3.2.1 Efficient Customer Response

Efficient consumer response (ECR) is a U.S. supply chain management strategy which attempts to address the inefficiencies which have led to excessive inventory and unnecessary costs at all levels within the grocery industry supply chain (Harris, 1999). The concept of ECR is based on vertical cooperation in manufacturing and retailing with the objective of an efficient satisfaction of consumer needs (Seifert, 2003).

There are four focus areas under ECR: Demand management, Supply management, Enablers and Integrators, which are intended to be addressed as an integrated set. These areas compose the basis of the ECR Global Scorecard [1]. On the supply management side, cooperation in logistics between manufacturers and retailers should result in optimal supply chain management. On the demand management side, collaboration in marketing via category management (Zenor, 1994) and the exchange of customer data makes it possible for all parties to achieve a more efficient marketing mix. ECR called for the creation of a timely and accurate flow of information, which heavily relies on Electronic Data Interchange (EDI) and strategic alliance between supply chain members (Sansolo, 1993).

3.2.2 Collaborative Planning, Forecasting and Replenishment

The CPFR (Collaborative Planning, Forecasting and Replenishment) (CPFR, 2000) is a business practice that aims at involving multiple trading partners in the planning and fulfillment of the customer demands. CPFR links sales and marketing best practices, such as category management, to supply chain planning and execution processes in order to increase availability while reducing inventory, transportation and logistics costs. CPFR is considered as a concept that emphasizes supply chain cooperation by supporting and assisting joint practices of cooperative management of inventory through joint visibility and replenishment of products throughout the supply chain. CPFR is the further development of ECR on the supply side. The purpose of CPFR is so to improve reaction time to consumer demand, direct and lasting communication (Seifert, 2003), and the performance of collaborative activities between manufacturer, seller and retailer while performing the following processes:

- *Strategy & Planning:* establishes the rules for the collaborative relationship. It determines product mix and placement, and develops event plans for the period.

[1] http://www.globalscorecard.net

- *Demand & Supply Management:* defines the project consumer (point-of-sale) demand, as well as order and shipment requirements over the planning horizon.
- *Execution:* places orders, prepares and delivers shipments, receives and stores products on retail shelves, records sales transactions and make payments.
- *Analysis:* monitors planning and execution activities for exception conditions. Aggregates results, and calculates key performance metrics. Shares insights and adjust plans for continuously improved results.

CPFR establishes guidelines for enterprises to integrate their planning processes across corporate boundaries. CPFR intends to ensure that the industry actually captures the benefits of inter- and intra-enterprise collaboration through a common, pragmatic approach. CPFR helps trading partners generate the most accurate forecast possible and set highly effective replenishment plans. Practitioners report major benefits in higher service levels, decreased inventories and increased sales (CPFR, 2000). Other benefits of CPFR include drastically improved reaction time to consumer demand and direct and lasting communication (Seifert, 2003).

3.2.3 Vendor Managed Inventory

VMI (Vendor Managed Inventory) is a supply chain strategy where the vendor or supplier is given the responsibility of managing the customer's stock (Disney and Towill, 2003). In VMI strategy, the buyer of a product provides information to a supplier on that product and the supplier takes full responsibility for maintaining an agreed inventory of the material, at the buyer's consumption location (usually a store). A third party logistics provider can also be involved to make sure that the buyer has the required level of inventory by adjusting the demand and supply gaps. Keys to making VMI work is shared information and cooperation trustworthy relationship between partners.

VMI changes the approach for solving the problem of supply chain cooperation. Instead of just putting more pressure on suppliers' performance by requiring ever faster and more accurate deliveries, VMI gives the supplier both responsibility and authority to manage the entire replenishment process (Kaipia et al., 2002). The advantages of VMI are to decrease cost, inventory level and complexity of supply and delivery, meanwhile, increase efficiency and service ratio with a clearer view of market requirements.

3.3 SME's specific problems towards supply chain cooperation

As previously mentioned, supply chain cooperation requires to maintain consistent working processes and a good customer-supplier relationship in order to perform and behave coherently and efficiently, but also require the use of enabling methods (like MRPII) and tools (like ERP systems). Normally, large companies have a good competence on these enabling methods and tools and are willing to invest and input resource to develop their relationship with other supply chain members and make it operational. SMEs are often in a different situation.

According to Dangayach and Deshmukh (2001), from the manufacturing strategy point of view, the key strengths of SMEs are flexibility, quick decision-making, high skilled competence and cooperation from employees, while weakness are the lack of technical superiority, lack of infrastructural facility and financial resources. Globalization has brought increased pressure on manufacturing SMEs who have to continually reduce prices against a backdrop of improving quality and services. For many SMEs, the expenditure on goods and services account for a high production of turnover and it is influential in the achievement of business objectives (Morrissey and Pittaway, 2004). In practice, the differences between SMEs and LEs are likely to influence the efficiency of the supply chain management, since building relationships with suppliers may be more difficult for SMEs than for large firms. SMEs do not always have a clear supply chain strategy and highly dependent on subcontracting, supplier's deliveries etc. Being under hard financial pressure, SMEs are sometimes considered as more cash focused (Brynjolfsson, 1994), more oriented on maximizing benefits in order to survive in competitions.

From the implementation point of view, the literature on supply chains suggests that SMEs and LEs implement SCM differently. Apparently, this difference in implementation is significantly associated with SME performance in supply chain (Arend and Wisner, 2005). Due to the low number of levels of the hierarchy and on the overlapping of responsibilities between the managers and planners, SMEs seems to be more flexible. In addition, the information needs of manufacturing SMEs in planning their internal supply chains are different from the large organization (Huin et al., 2002). Meanwhile, lack of effective adoption of SCM techniques was clearly pointed out in a study of 288 UK small to medium-sized industrial enterprises in (Quayle, 2003). Large companies commonly adopt different kind of information systems. For instance, in the aeronautical industry, most of the large companies use MRPII systems to organize and plan their procurement, production, distributions processes. However, SMEs do not always have the motivation for implementing such production management systems. Instead, they often define their own empirical way to process information, sometimes using Excel sheets or Access applications. Such differences have an important impact on coherent activities across supply chains, like information sharing, joint planning etc.

A group of studies focused on management components of the supply chain (Lambert et al., 1998) suggests some considerations on the behavioral side of the management that influences the SMEs towards SCM, including power aspects between companies, risk, reward structures, etc. Some findings suggest that since LEs consider SMEs as being easy to replaced, buyers may be reluctant to form partnerships with SMEs (Arend and Wisner, 2005). With a more positive point of view, "supplier development" (Leenders, 1996) is growingly capturing attentions in the buyer side. LEs may be willing to donate efforts in order to increase the number of viable suppliers and improve supplier's performance or capacity (Krause et al., 2007) through supplier development programs (Jensen and Jensen, 2007; von Axelson, 2009). From the supplier's side, SMEs do not deploy SCM; rather they often keep an arm's length relationship with large customers (Quayle, 2003; Arend and Wisner, 2005). Some cases show that the SMEs may view the SCM as the exertion of power by customers and consequently as a one-way process. One study claims, for example, that if a key partner forces a less powerful SME supplier to implement SCM, the performance in the chain will decrease (Arend and Wisner, 2005). In addition, since many SMEs are not used to or trained in wide-ranging risk assessments, SMEs desire clear and sufficient communication to decrease their own risks according to their roles in the entire supply chain. Besides, SMEs hold quite different attitudes towards cooperation with LEs. SMEs are always sensitive about the turnover from LEs, especially in high level of management, since such changes in LEs may lead to unstable cooperation towards suppliers. Therefore, SMEs often prefer to cooperate in more formal manners, such as fixing all the issues into the contract, rather than informal cooperation with a single high level manager from LEs.

4 Conclusion of chapter 1

In chapter 1, we have firstly introduced the concept of supply chain which involves a set of individual organizations working together for achieving products. These organizations operate on a product flow transforming raw materials into several semi-finished articles (parts, components, sub-systems) and finally into finished products towards customers. In parallel, information flows consists of orders/demand, updating status of inventory, and technical data mainly processed from downstream to upstream. Traditionally, the structure of supply chains is characterized by serial, convergent, divergent and conjoined structures. Each type of structure is applicable to different industries. Along with the changes of market and the ever growing competition, these traditional structures are evolving towards a more complex structure, the supply network. Supply networks are now usual in many sectors, including aircraft manufacturing industries. In addition, we have discussed the specificity of aeronautical supply chains, and described the involvement of the SMEs in such chains.

Secondly, we have stressed the concept of supply chain management and identified the existing models of supply chain management processes. In order to better organize the integrated processes, different levels of decision making (strategic, tactical and operational) have been introduced in the literature through several decision making policies, such as centralized decision making and decentralized decision making. Besides, many tools and methods are suggested to support supply chain management. The most popular ones are APS, MRPII /ERP, Lean/JIT and TOC (the latter being marginal).

With the present industrial context, characterized by more sensitive competition, highly customization and globalization, it is necessary for manufacturers to have a better visualization of the entire supply chain functions and maintain high level of efficiency, agility and flexibility. Therefore, cooperation between partners is emphasized as a key point for improving supply chain performance. We introduced the concept of cooperation in the last part of this chapter, trying to explain the different meanings attached to several close terms, like coordination, cooperation and collaboration. Accordingly, we suggested using the term "cooperation" in this study, representing the co-working among supply chain member pursuing the common goals and mutual benefits under an open and cooperative environment of motivation, mutual respect and trust, information sharing, jointly planning and decision making and better customer-supplier relationship. In practice, many methods, like ECR, CPFR, VMI etc. are proved as efficient ways to support cooperation in supply chains for different industries, but do not address all the aspects of the customer-supplier relationship.

In the next chapter, we will describe some case studies from the aeronautical industry, showing the actual situations of cooperation between customers and suppliers at different operational levels. From these cases, we would like to show that real practices are not always consistent with theoretical methods.

Chapter 2
Case Studies and Lessons Learnt

The efforts of academics and practitioners, as introduced in chapter 1, have already helped supply chain members to better perform and manage their cooperation with others. Because of the growing complexity of supply chains structure, of the increasingly sensitive competition and of the changeable market environment, analysis of real cases often shows the distance between theoretical models and the industrial reality. Aiming at better understanding the problems in real industrial situations, especially in the aeronautic sector, some examples of situations taken from cases studies are described in chapter 2.

1 Case studies

During the last few years, several members of our research team have been involved in projects aiming at analyzing or improving the cooperation in supply chains, among which APOSAR[2], which ended in 2010, is the most recent. APOSAR was conducted by the IODE federative structure[3], with partial funding from an association of companies of the aeronautic sector and from a public body interested in SMEs development. The objective of the project was to analyze the problems linked to the cooperation between partners of aeronautical supply chains on two main domains: collaborative design and product flow management (only the results concerning product flow management will be detailed here). Twenty companies were visited in that purpose: 7 large ones and 13 of middle (around 200 employees) or low (less than 100 employees) size. If the relatively low number of visited companies does not allow to fully guaranteeing the generality of the identified problems and situations, it is consistent with the results of previous projects on the same domain (Affonso, 2008) and shows that some existing problems are not yet fully taken into account by the methods promoted in the sector.

The main processes defining the relationship between customers and suppliers in the visited supply chains will be first presented. These processes are based on the interviewed companies' description of their working procedures at different levels. They will allow us to locate as a second step several problems showing the difficulties appearing in practice.

1.1 Practical structure of supply and demand process

1.1.1 Considered processes

The results of the interviews performed in the companies have been structured according to four main processes (Ming et al., 2009; Grabot et al., 2010):

- *Request For Quotation (RFQ)*
- *Forecasts processing (middle term planning)*

[2] APOSAR stands for Analysis of Organizational Problems in the Regional Aeronautical Sector
[3] IODE is a group of researchers in Industrial Engineering in the South West of France (http://idce.enit.fr/iode/)

- *Short term planning - Execution*
- *Audits/management of changes*

Only the first three ones will be detailed here. These three levels are consistent with the basic framework described in chapter 1 (see Figure 1.11) but are more detailed and include some specificities of the aeronautic sector.

The RFQ, aiming here at defining long lasting collaborations, is a long term and high level supply chain process (see Figure 2.1, all the processes being described using the ARIS model (Davis, 2008)). A RFQ describing the required part and the conditions of the program (prices, cycle times etc.) is sent to possible suppliers. The suppliers analyze this RFQ and send an answer, or detect problems either on the part definition or on the conditions, which they will try to negotiate. The customer receives the answers, compares them and selects one (or several) supplier based on his answer and on his previous performance, if the supplier is already known. A contract is then prepared, defining rough quantities to be ordered and prices through time. The selected supplier tries then to organize its production for the last months/years according to all the programs in which he is involved, for all the supply chains to which he belongs.

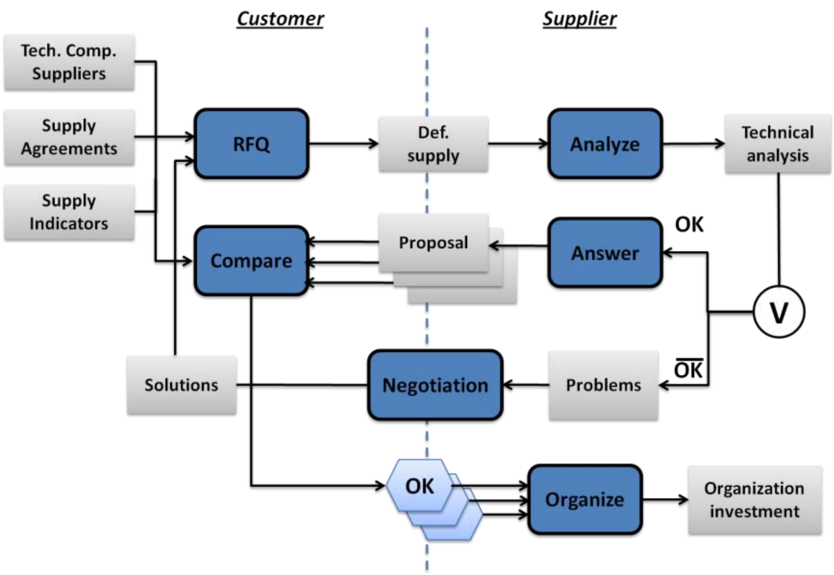

Figure 2.1. Request for quotations (ARIS formalism)

Forecasts processing is a middle term process (see Figure 2.2). It is based on an agreed standard about the various periods of the forecasts: firm period, flexible period and free period. In the firm period, the orders are confirmed by the customer. In the flexible period, supplier and customer agree on the limits of possible variations, e.g. ±20%. Within such limits, any orders changes have to be accepted. Any change can be performed in the free period, which is only considered as informative. The total of the three horizons may cover a period of two to three years in the aeronautic sector, to be compared to the cycle time of an aircraft, which is close to one year. The forecasts are updated every month or every two months.

After receiving orders forecasts from his customers, the supplier enters these forecast in his local information system (production management system based on MRP, planning on

Excel, etc.) in order to make a production plan. Accordingly, middle-term organization, raw material purchasing and supplier selection are performed to prepare the execution of this plan.

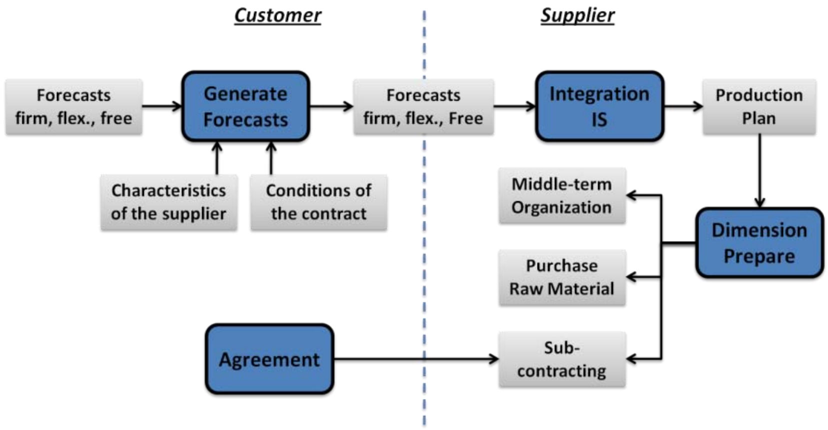

Figure 2.2. Forecasts processing

Execution is a short term process (see Figure 2.3). On the customer's side, the short term planning is made according to the mid-term planning, in accordance with the programs and terms defined in the contracts with the suppliers. The firm orders are confirmed regularly, allowing the supplier to build his own short term planning by taking into account the local inventories, available raw material and actual delivery performance of its own suppliers. In the aeronautic industry, urgencies (see top of Figure 2.3) can concern up to 30% of the parts for companies which are at the end of the supply chain, performing activities like thermal treatment. The most critical urgency is called "AOG" for Aircraft On Ground. These urgencies require quick adjustments at the supplier's side, usually combined with quick delivery from the supplier's supplier.

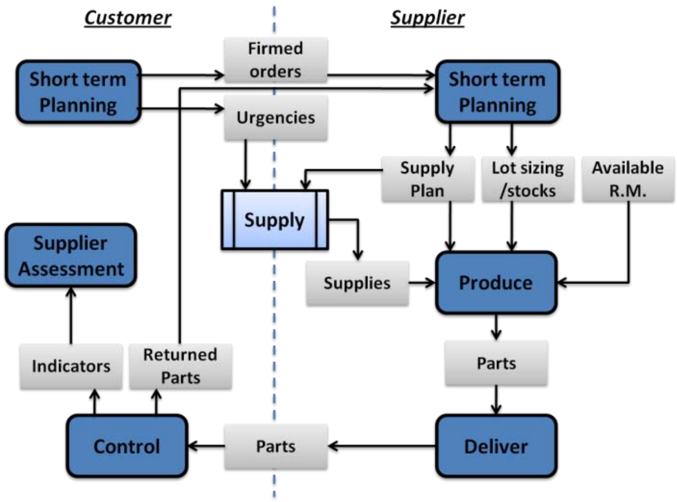

Figure 2.3. Short term planning – Execution

1.1.2 Basis of the contracts

It is clear that the management of supplier-customer interactions at different levels of the process is firstly governed by formal contracts, usually fixed in the RFQ process. Our primary focus here is the agreed items in the contract, which are related to demand and supply material/components, as well as the corresponding information flow.

We have positioned the information extracted from the interviews in the framework suggested by Anupindi and Bassok (2003), defining a set of parameters over which supply and demand contract is observed:

Horizon Length: This specifies the duration for which the contract is valid.

Case studies: Very different cases have been encountered during the interviews, but mainly contracts on several years, which can be broken at any moment if the customer finds better conditions elsewhere.

Pricing: This is interpreted with a broad sense in order to incorporate all financial flow. Clearly, one component for this is the purchase price. This could take several forms. For example, it could be linear (proportional) or non-linear (e.g., two-part tariff). In addition, other types of payment structures can be set up. For example, credit for return of goods by a buyer, holding cost subsidies from a supplier to a buyer, payments for inability to supply (e.g., due to stock-out), etc. Thus pricing may be also depend on other parameters of the contract.

Case studies: The characteristic observed during the interviews in the decrease of the price through time, obliging the supplier to gain productivity every year or to submit initial prices including an extra margin, with the risk to be more expensive than the other suppliers.

Periodicity of Ordering: This specifies how often a buyer can place orders. It could be fixed (for example, a buyer may be asked to place orders at the beginning of each month), or random (any day of the month).

Case studies: Very different cases have been seen here, for instance: order by day for the firm orders, by week at mid-term, and by month at longer term. For others, the orders were planned by day on the whole forecasting horizon, even if their precise positioning will be set into question through time.

Quantity Commitment: Quantity Commitments by a buyer could be on orders, its demand, or capacity of the supplier. Order Commitments take two generic forms:

- *Total Minimum Commitment:* for single products, this implies that a buyer commits to cumulative purchases of at least a certain quantity; this is referred to as Total Minimum Quantity Commitment. For multiple products, this usually takes the form of commitments to purchase at least a certain minimum value of goods, referred to as Total Volume Commitment.
- *Periodical Commitment:* A buyer makes a commitment to purchase a certain quantity every period.

Case studies: Again, different cases were denoted by the interviews, especially in the flexible period: for instance, quantities cancelled during the flexible period were to be accepted by the customer before the end of the year in some cases. The goal is here to keep some flexibility without destabilizing the supplier.

Demand Commitment: Under demand commitment a buyer commits to source a fraction of all his demand from a specific supplier. Let us observe that under such commitment, the uncertainty of the demand process is shared with the supplier.

> *Case studies: To our knowledge, this specific type of partnership does not seem to be currently used in the aeronautic sector.*

Capacity Commitment: under capacity commitment, a buyer usually reserves a fraction of the supplier's capacity. For example, in agricultural contracts, a buyer commits to buy all production from certain acreage; in the semiconductor industry, often buyers purchase a certain fraction of the capacity of a supplier's foundry wafer fabrication facility.

> *Case studies: Capacity commitment seems to quite rare, but has been mentioned by several large companies, who would like to secure the reliability of some critical suppliers, like those providing thermal treatment or some specific raw materials. It is clear that such contract seems to be based on a weak position of the customer regarding his supplier.*

Flexibility: Whenever a buyer makes some commitments on the quantities to be purchased, it is asked to the supplier to provide some flexibility allowing him to be able to adjust these quantities through time. The contract may specify the magnitude and frequency of adjustment. For example, a supplier may specify the additional (unlimited) quantities which may be ordered, but no more than two times during the contract horizon. In the contracts with restrictions on the magnitude of commitments, the extent of adjustments allowed may or may not be a function of the commitment made. Furthermore, the additional flexibility may come at extra cost to the buyer.

> *Case studies: In the aeronautical domain, flexibility seems to be universally handled through firm, flexible and free periods in the forecasts, as defined above.*

Delivery Commitment: A supplier usually makes a commitment for the material delivery process. A commitment on the lead time would specify the delay in delivery of the material. Service level agreements on the lead time for the entire orders or on fractions of the orders are common. Of course, this is usually coupled with a mutual agreement upon shipment policy. A shipment policy will specify if a buyer accepts multiple shipments for the same order.

Case studies: Delivery commitment usually includes an agreement about the cycle time for each product, but this cycle time may be real (the supplier only needs this time to manufacture the product) or more often, apparent. In this case, the supplier must have raw materials or sub-components available in order to satisfy the constraint of the cycle time.

Quality: Quality restrictions could come in terms of defects rates, specification, etc.

> *Case studies: The aeronautic sector is of course a domain where quality is of prime importance. Usually, the supplier engages himself to only deliver good parts, but quality is sometimes not a binary evaluation, and negotiation is often used for obtaining dispensation on non-critical points.*

Information Sharing: This characterizes the information flow between a buyer and a supplier. Specifically, it outlines what type of information will be shared between the buyer and a supplier. For example, a buyer (retailer) may pass on the sales data to its supplier.

> *Case studies: Again, very different practices have been seen, linked to the customer but also to the supplier. Some suppliers only send orders, and ask to be delivered on time. Others send additional information, like their present level of inventory on the concerned part, in order to show the level of priority of the order to their supplier (we shall come back to this point later on). Some suppliers give access to their customers to a web site on which the status of the order is actualized day by day. Information sharing on the manufacturing processes is also possible, but the suppliers are often reluctant to share all their knowledge with their customer.*

Penalties: Even if they are not mentioned in (Anupindi and Bassok 2003), penalties in case of late deliveries are often included in the contracts concluded in the aeronautic sector. Nevertheless, these penalties are seldom applied:

> *Case studies: during the interviews, several logistic managers of large companies explained that late deliveries were the external symptom of organizational difficulties of the supplier. Adding penalties is only a way to destabilize the supplier still more, and it is usually preferred to ask him to launch improvement projects. Therefore, penalties seem to be more dissuasive than really applied in the aeronautical domain.*

1.2 Practical operations in case studies

The usual solution to perform such supply and demand processes, which is promoted for coordinating the partners, is through a cascade of local MRPII systems (see Figure 1.11 in chapter 1). Forecasts based on the expected customer's demand are built by the focal company of the chain (usually the final assembler in the aeronautic sector) then processed using the MRPII principles. After the MRP step, planned orders allow to build a supply plan (including forecasts) which is sent to the tier n+1 partners. We will take a simple example to show the usages of MRP as promoted by the large companies.

1.2.1 Use of MRP as promoted by the large companies

As already seen, the end-products are manufactured in the aeronautic sector on the base of firm orders but also forecasted ones, including a firm, a flexible and a free period. The idea is then that, in consistence with the principles described in chapter 1, the forecasts will be propagated upstream the supply chain in order to allow each partner to manage its production. Let us take an example for illustration (see Figure 2.4): the focal company A builds his sales forecasts based on firm orders and expected ones at long term. If the cycle time of its product (for instance an aircraft) is one year, the firm period of the forecasts should be at least one year (but preferably more). Let us suppose that this cycle time is the addition of an internal assembly process equal to six months plus external supplies requiring six more months. Let us consider that these additional six months are divided into: two months for the internal work of supplier B, and four months for the supply of the raw materials (supplier C). As a consequence, if the customer does not confirm a forecasted order expected on month 13, company A will have to cancel an internal load positioned on months 7 to 13, together with an order sent to supplier B due on month 5. This order was to be released on month 4 at B's side. As a consequence, supplier B will have to cancel an order he planned to send to his raw material supplier C next month (left part of Figure 2.4).

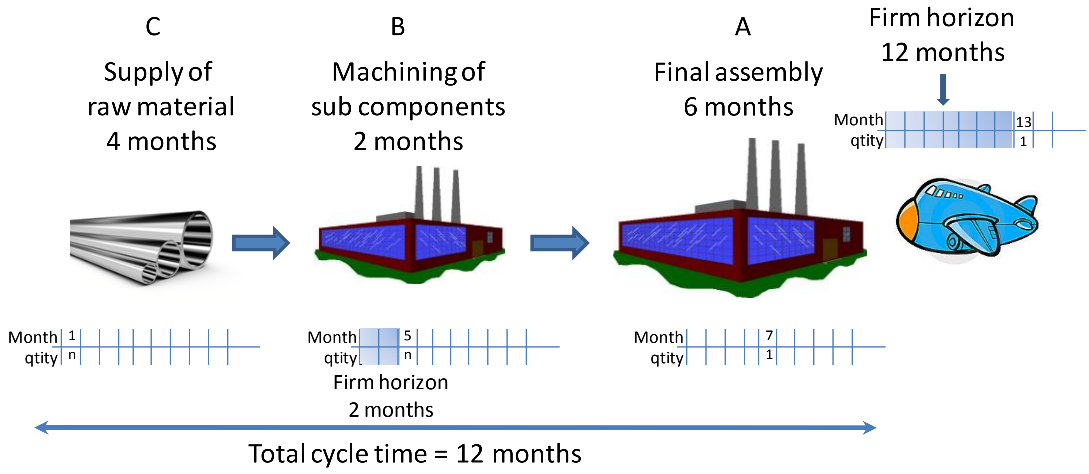

Figure 2.4. Cycle time and firm horizon

As shown in the previous section, the lead time of the suppliers, as well as the prices, are discussed during the RFQ process. Indicators aiming at measuring the performance of the suppliers (mainly based on a service ratio) are also defined.

According to this "theoretical" framework, the key issue is to check that each partner of the supply chain (and especially the smallest ones) is able to process his forecasts and turn them into an internal load planning and an external supply planning using the MRP process. As it will be shown in next section, reality as perceived in our case studies is somehow different and more complex.

1.2.2 Anomalies and additional local practices

Many problems were identified in the previously described processes during the interviews. We shall not give an exhaustive list here, but shall focus on some problems which have influenced our study.

I. Linked to the firm period of the forecasts

The first issue identified during the interviews is that the parameters of the forecast periods, but also the practices which result from the interpretation of these parameters, may be quite different from one company to another. Reality appears to be often less consistent than the principles illustrated in Figure 2.4, since it is the market (and not the focal company) which decides on the lead time acceptable by the customer. This pressure set by the market is sometimes transmitted to the suppliers, e.g. for raw materials.

During several years, a relative scarcity of some aeronautical alloys together with a lack of capacity of companies providing casting parts made that the supply time of raw materials increased up to 12 months in some cases. In spite of this, the firm period of the forecasts sent by the customer to their supplier remain constant, around 3 months, compelling the suppliers to take the risk to order materials on the base of flexible forecasts, or to be late if they were waiting for the corresponding orders to be confirmed.

> *Example: A company manufacturing small (and highly customized) aircrafts has a firm horizon of 12 months, whereas its supply time for the motors is 14 months, the variant of the motor being chosen by the customer.*

II. Protection or pressure using the periods of the forecasts

Some (rare) companies use the difference between the firm period received from their customers and the one sent to their suppliers as a way to protect their smallest suppliers, who may have difficulties for dealing with large variation of the demand. If an SME is not protected from these risks, the poor delivery performance due to SME's capacity limitations may impact the performance of the customer.

> *Example: A large tier 1 company mentioned that the importance of one of his customers obliged him to accept that all orders (even firm ones) could be cancelled until reception. However, the company did not set into question the firm horizon sent to his own suppliers, but introduced high flexibility ratios (±50%) in the flexible zone. In order to make this acceptable, they decided that if the ordered quantities decreased too much in this flexible period, they would anyway buy the cancelled parts by the end of the year.*

III. Load smoothing

When SMEs are involved in a single industrial domain, as it is often the case in the aeronautic sector, the periods of low or high demand may be the same for their various customers, all submitted to the same markets, which decreases the theoretical interest of having diversified customers. Load smoothing may then become an important issue for the SMEs. During the periods when the load is important, the result is often that some orders are delayed (this issue is addressed in other sections). When the load is low, SMEs are looking for work, and it can be tempting to work in advance on some expected orders which have not yet been confirmed.

> *Example: A supplier explained us that during a difficult period, he decided to work on orders belonging to the flexible period of the forecasts sent by his customer, even if he was not sure that these orders would be finally confirmed. For him, the risk was limited and the over cost linked to the late payment and increase of inventories was less important than the cost required to temporarily decrease his capacity. In addition, he wanted to show his reliability to his customer, which was easier with such an early production.*

IV. Protection against variations of load

Similar to point III, many SMEs have mentioned their problems regarding load variations, either linked to an increase or decrease of the demand, even if this variation was consistent with the quantities negotiated per period. Indeed, variations of the demand from one period to another may be difficult to handle for SMEs, especially if similar variations come from multiple customers. In the case studies, we have seen some cases where this problem was formally taken into account by the customers willing to protect their smallest suppliers.

Example: A customer wanted to protect its smallest suppliers from load variations. As a consequence, a maximum variation between two consecutive periods was considered as a constraint for building the supply planning. The consequence was that the customer had to anticipate any variation and to increase his inventory level in order to cope with the demand of its own customers, varying more dynamically.

V. Link between price and cycle time

As already mentioned, satisfying urgent orders usually means to spend extra money (through extra hours, etc.) or to postpone other orders considered as less urgent, creating perturbations in the planning. However, as already noticed, in practice, most of these urgencies do not seem to concern parts which are urgently needed for the final product, but are mainly linked to local interests (e.g. the customer has to increase his service ratio for the next period). In some very specific cases, we have seen that the principle of a priority negotiation of the price and cycle time could be considered in order to address the problem of these urgencies.

Example: A SME, who has a strong position because of the scarcity of his competence (surface treatment), had a quite original approach: it managed to impose to its customers that only three cycle times were possible (10 days, 15 days, 20 days), with decreasing prices. This was also a way to deal with urgencies, which were considered under condition that the customer was ready to pay for short cycle times.

VI. Information sharing

Many SMEs are facing a demand that they can hardly satisfy at low cost, mainly because of overloads or variations. Several logistic managers at the customer's side were conscious that they were setting a hard pressure on their suppliers, but explained us that even if they could guess that some of the orders still had some slack time, they were themselves not informed of this, and were therefore unable to help their suppliers to prioritize the orders. As a consequence, the SMEs have to make their decisions, for instance on priority of orders, grouping of similar orders, adjustment of lot size, etc. only based on their internal considerations. Such lack of information sharing between supplier and customer may lead to conflicts. In the case studies, we have nevertheless seen that some customers share information with their suppliers in order to allow them to make their decisions to the benefit of both partners.

Example: A large company in tier 1 was sending the level of its present inventory together with each order, in order to show his supplier what could be the consequence of a late order. Sharing information on the inventory level provides the supplier with information related to the customer's interests when it is necessary for him to postpone orders, and increases his flexibility when constraints occur locally.

VII. Linked to lot size

In the process of RFQ, lot size is an important item in the contract but as previously stated, SMEs have to decrease their costs through time, and have so to find solutions for increasing the efficiency of their production system. In order to do this, most of them consider first immediate but questionable solutions like increasing lot sizes, more than long term ones like simplifying the production system through techniques like lean manufacturing. Therefore, many suppliers try to group various orders from their customers in order to increase their lot sizes, and decrease the set-ups.

> *Example: An SME specialized in turning showed us that once the production plan of the next months was introduced in their production management system, they performed an extraction and used an Access-based application for grouping the orders according to the diameter of the parts, which was not possible using their production management system. The problem was that their application was not taking into account the due dates, with the result of both early and late orders which were then negotiated individually with the customer.*

VIII. Industrialization/quality

Other problems were mentioned by the visited SMEs, for instance linked to industrialization: many companies claimed for instance that the parts described in the RFQs were in some cases impossible to manufacture, because of too constraining tolerances. The SMEs were considering that the customers were over-constraining their design, and do not always assess the consequences of tolerances in terms of costs and scraps. As a consequence, the suppliers had to commit themselves on delays and costs whereas they were sometimes conscious that they would not meet either of them in the future. The position of the customers on this problem was of course different, since they were considering that more and more precise tolerances were required by nowadays products and that the SMEs have some problems for mastering their processes.

IX. Usage of production management systems

Several problems were also linked to the way the SMEs used their production management tools. The basic point was that the requirements of the large companies regarding production management tools and techniques were not understood by some SMEs, considering production management as an administrative work (sometimes performed by a secretary). Most of them had already bought and implemented a production management system, but it was clearly under their customer's pressure, and the effort to set the tool operational was not always done. As a consequence, the production management tools ware often only used to enter the customer's orders, then to edit manufacturing orders, without any planning step. In one case, the SME had recently discovered that their production management system was able to create a load planning, allowing them to control their load/capacity ad-equation at middle term, which they were not aware of.

Limitations were also detected linked to the production management systems which were used, since systems dedicated to pure MTO (Make-to-Order) are still in use in some SMEs, whereas the production context has changed in the aeronautic sector. A consequence was for instance that all the forecasts were sometimes introduced in the system as firm orders, resulting in many difficulties for distinguishing then between real confirmed orders and forecasted ones.

1.2.3 Summary

Even if the generality of these practices cannot be demonstrated on few examples, they are indeed consistent with the conclusions of the previous projects conducted by our research team on the subject, but also with the feelings of several consultants of the aeronautic sector, involved in the APOSAR project or interviewed externally.

We have quite often seen during the interviews that people were putting some emphasis on other issues than purely technical ones, often speaking of trust, maturity, involvement, goodwill etc. Looking back to the cases we have presented, these practices are linked to specific situations: relative weakness of a supplier, dependence of a customer towards his supplier, trust (or distrust) between partners, etc. It seems to us that these conditions are closely attached to different types of supplier-customer relationships and cooperation situations in the supply chain. Therefore, the problems in supply chain cooperation are not only technical oriented, but depend also on the behavior of supply chain members, supplier-customer relationship and cooperation situations.

Two approaches are possible when considering these problems: many customers, aware of them, consider that they are the proof of a lack of maturity of their suppliers (but also of themselves). For them, the solution is then to increase maturity through “supplier development”. In that purpose, many projects have been launched during the last five years aiming for instance are disseminating the principles of MRP and lean management in the SMEs of the aeronautic sector. This is indeed a long term approach, and we have decided in this thesis to explore another direction: for us, practices are linked to actual needs, closely attached to relationship between supplier and customer, even if their result can be considered as negative. Therefore, the idea in this thesis is to accept to analyze practices which are not consistent with present industrial habits, in order to objectively assess their possible area of interest.

2 Conclusion of chapter 2

Chapter 1 allowed us to give some basic considerations on what is a supply chain, what is supply chain management, and how to coordinate partners in a supply chain. In chapter 2, we have analyzed some elements of case studies which allowed us to have a direct access to practices of large and small companies in the aeronautic sector. The specific case of SMEs in aeronautical supply chains has been introduced, and some of the problems linked to the cooperation between partners of aeronautical supply chains have been discussed. These studies have clearly showed us that reality is somehow different and more complex than the “theoretical” framework previously described.

Since most of the problems we have identified are, in our opinion, linked to a lack of consideration of the partner’s interest, we have decided to try to re-formalize some of the empirical practices identified during the interviews, in order to increase their efficiency and decrease their drawbacks. On the other hand, we have seen some good practices in the interview which could be considered as examples of good cooperation and provide some preliminary ideas for better information sharing and negotiation. Therefore, we shall try to include practices identified in the interviews in a negotiation process in chapter 3 and chapter 4.

Indeed, these practices are dependent on what kind of relationship customer and supplier are holding, as well as on the situation of cooperation of the supply chain. For instance, looking back to the cases we have presented, we have seen that some identified practices are linked to specific situations: relative weakness of a supplier, dependence of a customer towards his supplier, trust (or distrust) between partners, etc. It is obvious that information sharing and mutual negotiations are dependent on the relationship that supply chain members are holding. Thereby, it is necessary to identify cooperation situations in supply chain, which are closely attached to supplier-customer relationship. We will introduce this part in chapter 5.

Chapter 3
Negotiation Process in cooperation situations

In chapter 2, we have identified some practical problems in the cooperation process between large companies and SMEs in the aeronautical sector, which have shown us the gap that may exist between "theoretical" frameworks and real practices. Nevertheless, some practices have provided good examples of ways to reduce this gap by publishing hidden problems and taking into account interests of both customer and supplier. Therefore, in this chapter, we firstly try to present some lessons learnt which bring new ideas for dealing with complex cooperation problems then suggest a negotiation process concerning issues which are usually not discussed, but may lead to a better global performance of the supply chain.

1 Lessons learnt from interviews

Looking back at the industrial interviews, important problems have been described in the purchasing of raw material/component and on the delivery of the requirements. Therefore, we have especially focused on the related aspects of the supply and demand process, such as period of forecasts, load variations, order priorities, lot sizes, or purchasing cycle times, which were the objects of many hidden practices, especially from the suppliers. Meanwhile, we have considered lessons learnt from some cases, which provided us the basic ideas of a negotiation process which would allow to turn these empirical / hidden practices into agreed/negotiated behaviors.

Normally, the agreements between customer and supplier concluding the RFQ process aims at defining fixed parameters, such as periods of the forecast (which are seldom negotiated), purchasing price, product cycle time, delivery lot sizes, rough quantities in given periods, etc. However, some real situations led us to consider that when practical problems have to be solved, making these fixed items flexible may in some cases bring a better demand and supply performance. Some cases have already shown examples of such empirical practices, for instance by adjusting prices, cycle times or lot sizes to a given specific situation. Meanwhile, such adjustments may be useful not only in the RFQ process, but also in the operational one. Thereby, we believe that extending the negotiation process between supplier and customer to operational aspects could in some cases bring to better performance of the supply and demand process, and could accordingly contribute to build an effective cooperation relationship. In the next section, we propose some main items that could be negotiated by customer and supplier, at different levels of planning, using the MRPII method. We are conscious that most of these suggestions can be considered as inconsistent with industrial habits, or may result in increased problems rather than in better performance. Therefore, we shall discuss in the following chapters the conditions which would have to be verified for making these suggestions realistic. Nevertheless, we also think that a drastic increase of the performance needs some rupture with previous habits, in a similar way that just-in-time or lean manufacturing are in many aspects in rupture with traditional manufacturing methods. Therefore, we do not want to select solutions *a priori* because of their consistence with existing behaviors, but to assess their real potential before defining in which situations they could be used.

2 Basis of negotiation processes from interviews

Our goal here is not to suggest a so-called “optimal” negotiation process, but to take some real empirical situations from case studies as examples, and try to include them into a consistent formal negotiation process, in order to check their real potential. Therefore, the cases mentioned are not for us a closed list, but an illustration of what can be brought by extending the objects of the negotiation process, which may concern quite different aspects. In the proposed negotiation processes, we shall first consider four items based on the case studies: periods of forecasts, load variation, price and cycle time, then order priority and lot sizes (Ming et al., 2012a).

2.1 Period of forecast

As mentioned previously, in the aeronautical industry, the forecasts usually consist of firm, flexible and free periods. Since the free period has no operational impact, we shall discuss here the interest of putting the length of the firm and flexible period in the proposed negotiation processes.

The periods of forecasts are usually defined by the customer, and may lead to problems detected by the supplier (see Figure 3.1). As seen during the interviews, practical issues concerning the various periods of the forecasts are for instance the link between the firm period and the cycle time of the orders (see point I, in chapter 2, section 1.2.2); or the link between the lengths of the periods received by the customer, and those he sends to his suppliers (see point II, in chapter 2, section 1.2.2).

In both cases, the real issue is risk: risk taken by the supplier when he orders raw materials or releases production orders (see point III, in chapter 2, section 1.2.2) on the base of the flexible period of the forecasts he receives, and risk taken by the customer when he accepts to send to his supplier a firm period longer than the one he himself received from his own customer.

Indeed, the lengths of the periods of the forecasts are a mean to share risk (or not): as stated above, sending the supplier a firm period longer than the one the customer receives means to protect the suppliers, but sending the same firm period than the received one (minus the internal cycle time) means transmitting the pressure on the suppliers. Sending a firm period shorter than the one received would mean to try to gain some slack time by urging the suppliers more than really needed.

However, the necessity of protective behaviors also depends on the actual situations at the supplier’s side. If the supplier may be destabilized by variations of the demand, such risk sharing or protecting behaviors may be favorable for both customer and supplier. However, if the supplier is capable to adjust his capacity and manage the corresponding risks, protecting behaviors are less essential, and may lead to extra costs for the customer. Therefore, we propose as a global idea to put the periods of forecast into the middle term negotiation process, which would allow to make the length of the periods and possible variations in the flexible period more flexible, being negotiated on the base of the real requirements and actual necessities of both customer and supplier.

Figure 3.1 presents the suggested information flow between different levels of plans and the main activities defined in the negotiation on periods of forecast. The information required for risk assessment comes, on the customer's side (see right part of Figure 3.1), from a comparison between the MRP step and the horizon from customer's customer. On the supplier's side (left part of the figure), it comes for instance from a comparison between the load planning level (allowing to coordinate supply plan and production plan) and the periods of forecasts sent from the customer. Based on a risk assessment, negotiation of the periods of forecast may be performed if the supplier or the customer consider (independently) the current risks they take as unacceptable.

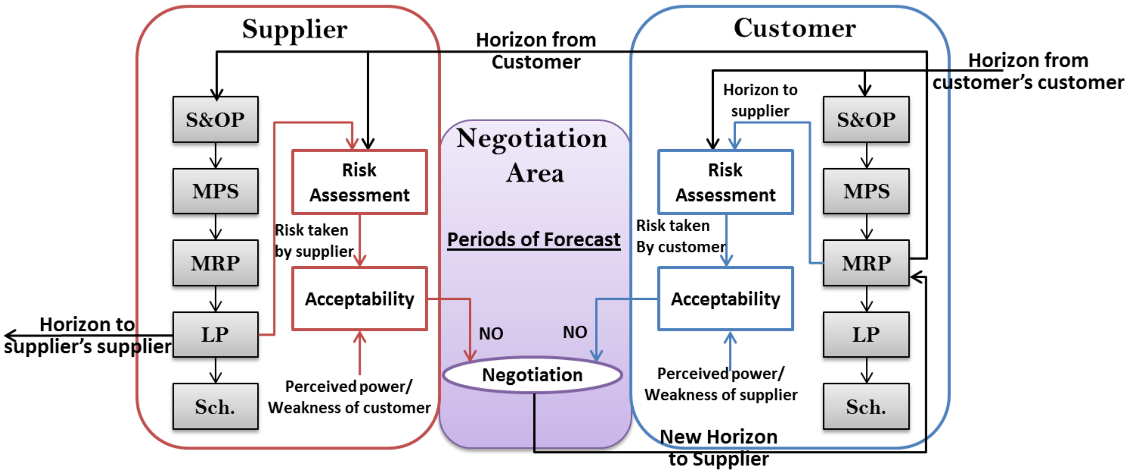

Figure 3.1. Negotiation on Period of Forecast

2.2 Load variation

The second item we suggest to discuss, load variation, can generate problems at both customer and supplier's sides. The capacity of the suppliers being usually limited (especially because low prices are poorly consistent with overcapacity, but also because of the present increasing workload in the considered sector), it is certainly dangerous for the customer to send an irregular load to his suppliers. The allowed variations in the flexible period are supposed to avoid such cases, but we have seen that the contractual variations may be very important (we have for instance seen an example of ± 50%). In point IV of chapter 2, we have also seen that some customers try to limit the load variation between two consecutive periods even if it would be allowed by their contractual agreement. Nevertheless, this protective attitude is perhaps not always necessary since the supplier can perhaps be able to cope with this variation if the price paid by the customer covers his extra costs, linked to a temporary increase of its capacity or to sub-contracting.

Therefore, instead of considering that the supplier HAS to answer to an overload if it is consistent with the contract, or CANNOT answer to an important overload (in consistence with the contract or not), overloads (same for lacks of loads) could also be negotiated, including setting into question the corresponding price paid by the customer.

On the customer's side, information concerning the load variation is estimated at the MRP level, while real problems of capacity/load are usually detected in S&OP and load planning level on the supplier's side (see Figure 3.2). According to his real situation, the supplier should decide whether he requests for negotiation or not. On his side, if the customer estimates that load variation may induce problems for his supplier, he may also request negotiation.

The problem may also exist on the supplier's side, usually involved in several supply chains (see left part of Figure 3.2). In case of lack of load, the supplier could ask the customer to manufacture earlier some orders (see point III, in chapter 2, section 1.2.2). As a result, he requires his customer to accept a temporary increase of inventory due to an early delivery, and should encourage this by decreasing his price in order to share the consecutive over costs and risk. Similarly, an overloaded supplier could ask his customer to accept some delays in the deliveries, and could in that purpose accept to temporarily decrease his prices.

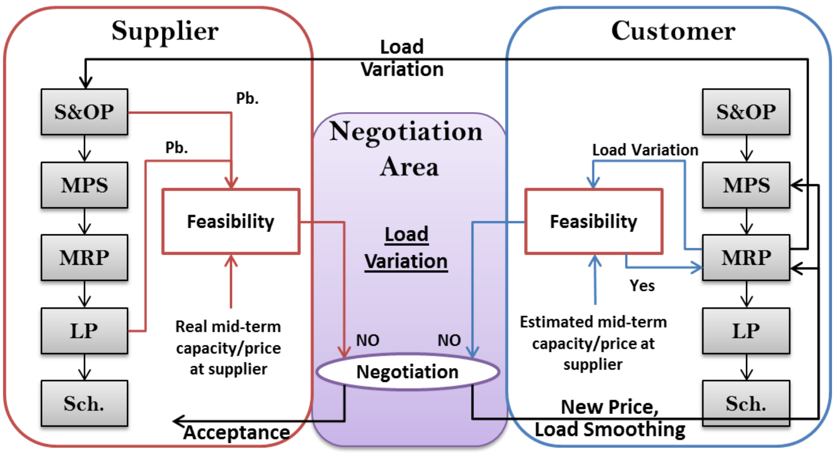

Figure 3.2. Negotiation on Load Variation problems

Therefore, we suggest to negotiate load variation problems, either resulting from constraints at the supplier's or customer's side, with a direct link with the price (increase if the problem comes from the customer, decrease if the problem comes from the supplier).

2.3 Prices and cycle time

As already mentioned, urgent orders are quite usual in the supply and demand process of the aeronautical industry. We distinguish this point from the previous one in the sense that overloads can be detected quite early, in the flexible period of the forecasts for instance, their consequence being analyzed at the S&OP level, whereas urgencies have to be handled at short term, often in the firm period. Urgencies are of course firstly detected at the customer's side, but when facing these urgencies, it is the supplier who is challenged through its flexibility and adjustment of capacity (see point VI, in chapter 2). Therefore, it can be considered as in Figure 3.3 that the problem of the cycle time for quick delivery is detected at the operational level of the supplier.

Usually, the urgencies are processed by the supplier depending on the influence of the customer over him, with the result of possible disturbances on the short term planning propagated to other customers. Two cooperative behaviors could help to mitigate these problems: the first one would deal with the price, allowing the supplier to find extra capacity for processing the urgent parts, whereas the second one would deal with a better negotiation on the priorities between the supplier and his customers.

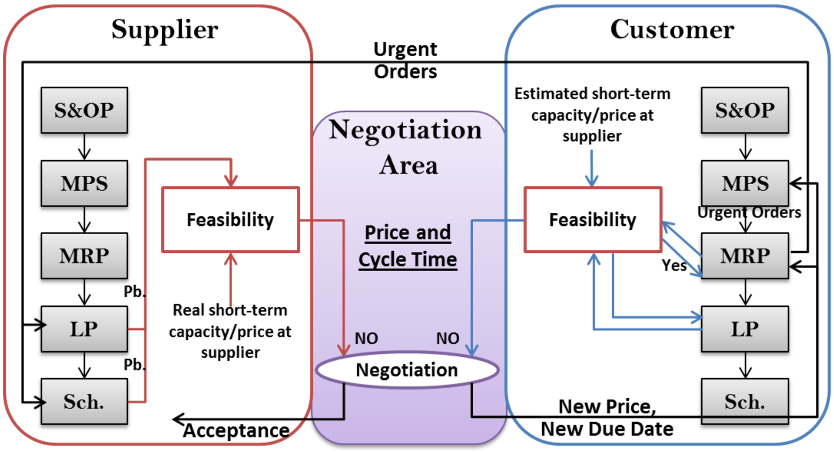

Figure 3.3. Negotiation on Price and Cycle Time

Concerning the first point, we shall consider here that the cycle time of urgent orders is partially negotiable, as well as their cost (see point V, in chapter 2). When an urgent demand occurs, the customer should pay for the cycle time he expects according to the situation of his supplier; for instance, no increase of price would be required if the supplier is in an under loaded period but in other cases, a negotiation process on price and cycle time is suggested to cope with the constraints due to the supplier capacity. Indeed, an increased price paid by the customer may allow the supplier to increase his capacity in order to fulfill the urgent delivery requirements (if the raw materials are available). The second point, negotiation of orders priority, will be addressed with more details in the next section.

Figure 3.3 presents the information flow during the proposed negotiation on price and cycle time. On the customer's side, the information for assessing the feasibility of an urgency is created in the MRP and load planning levels, while real problems dealing with such urgency come from the load planning and real-time scheduling levels on the supplier's side. The new price and due date which are the results of the negotiation are considered by the customer for assessing whether the urgency can be considered as properly addressed or not.

2.4 Orders priority and Lot sizes

The final item we suggest to put into the negotiation process is the orders priority and lot sizes. From the interviews, we have seen real cases where SMEs are trying to regroup orders having common features, usually in order to decrease the set-up times by increasing the lot sizes (but other reasons may exist). Such regrouping at the MRP level on the supplier's side, if not done properly, could possibly lead to early or delayed orders (see point VII, in chapter 2, section 1.2.2). Without additional information from their customers, it is also common that the suppliers use an internal priority for scheduling the orders at the operational level if all the orders cannot be fulfilled in time, as well as when urgent orders are required (see point VI, in chapter 2, section 1.2.2). As a consequence, tardy orders for one or several customers may occur. Temporal margins or safety stocks may allow the customer to face delayed delivery from the supplier on some of the orders, but this information is not always shared with the suppliers.

We have chosen here to group these two issues in the same point (see Figure 3.4), since they both deal with operational planning.

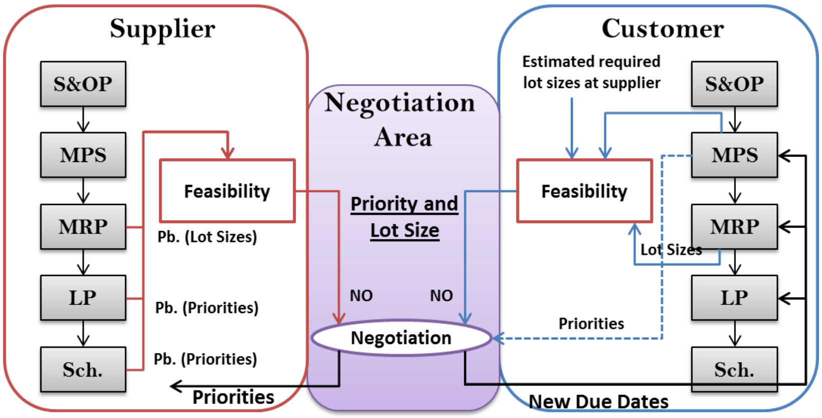

Figure 3.4. Negotiation on Priority and Lot Size

We have seen that practices have been detected in our case studies aiming at decreasing this problem: see the large company sharing his inventory levels (point VII, in chapter 2 section 1.2.2), allowing his supplier to have an indirect vision of the real priority of the orders. This allows the supplier to make better decisions when it is necessary to postpone orders. We have also seen that minimum lot sizes can be agreed when the contract is established (point VIII, in chapter 2 section 1.2.2). In order to go one step further, we suggest to introduce these points in a negotiation process, at middle term (lot sizes), then short term (priorities). Again, extra payment would be an element of the negotiation, as in the negotiation on cycle time previously suggested.

Figure 3.4 shows the information flow concerning the negotiation on priority and lot size. On the supplier's side, problems related to lot sizes are identified in the MRP step, while the problems linked to priorities (needing finite capacity analysis) are detected at the load planning and scheduling levels. On the customer's side, problems are only estimated since the customer does not have a direct access to the information allowing him to precisely know whether he will generate problems for his supplier or not. This estimation is based on information collected possibly at the MPS level, but mainly at the MRP level. If negotiation is performed as required by the supplier, the customer provides information regarding the internal priorities in order to reach mutual agreement.

2.5 Synthesis

Based on lessons learnt from case studies, we suggest a negotiation process across different stages of production, in which parameters which are usually defined in the contract between customer and supplier, like periods of forecast, load variation, price and cycle time and orders priority & lot sizes, would be considered as negotiable when problems are detected. Negotiation on each item should be based on an analysis of the context, e.g., firm period and limitations in the flexible period are negotiated only when one of the partners needs to be protected, etc. A satisfactory negotiation on these items could lead to a more effective cooperation between supply chain members, allowing to share some of the risks related to various aspects of the production process.

Nevertheless, the items in the negotiation processes as shortly described in previous section are not all independent. Due to the constraints at the supplier's side, problems of order priority and load variation are for instance closely linked to capacity issues. Load smoothing can also be performed by acting on the lot sizes at the supplier's side, and order priority may influence the short term load. Furthermore, all the suggested items in the negotiation process influence costs. For instance, extra costs arise from adding capacity at the supplier's side, storing products more than planned at the customer's side, re-planning the transportation etc. Accordingly, extra payment, for instance compensating an extension of capacity at short term, or paying for cancelled orders, may be considered. Some details on the negotiation process we suggest will be given in next section. These details also aim at defining conditions of tests for illustrating the domains of interest of such negotiations.

3 Specified negotiation process

The previous section has provided a general overview about each negotiated item, period of forecast, load variation, price and cycle time, and orders priorities and lot sizes, according to some practices ("good" or not) identified during the interviews described in chapter 2. It is not yet sufficient for clearly answering the three main questions allowing to precisely define such negotiation, i.e.:

- *When is there a need to negotiate these items? (Detect constraints and conflicts)*
- *At which level should these negotiations be handled? (Find right levels and activities in the process)*
- *What is needed to perform such negotiations? (Define the required information)*

Therefore, we will go further to specify each suggested negotiated item, showing the corresponding business process model and its sequenced activities, as well as other required information (Ming et al., 2012b). Aiming at achieving a simple and clear vision on the proposed negotiation process, we will focus on the extra costs aspects, which are of course the main result allowing to assess the interest of the negotiation. Details are showed in the coming section. We have chosen the Business Process Diagram (BPMN, 2011), which is now a recognized standard, for describing the negotiation processes.

3.1 Negotiation on period of forecasts

3.1.1 Business Process Diagram

The Business Process Diagram of the negotiation on the periods of forecasts is summarized in Figure 3.5. Normally, forecasts coming from customer's customer are inputs of the S&OP plan and then used to generate the MPS (Master Production Schedule) (point ① in Figure 3.5). MPS gives more detailed production requirements to the MRP (Material Requirement Planning) module (point ②). The supply plan, one of the outputs of MRP, is generated based on the BOM (Bill Of Material), supply lead time, material inventory level, etc., according to the contractual horizons, including lengths of firm, flexible and free periods (point ③).

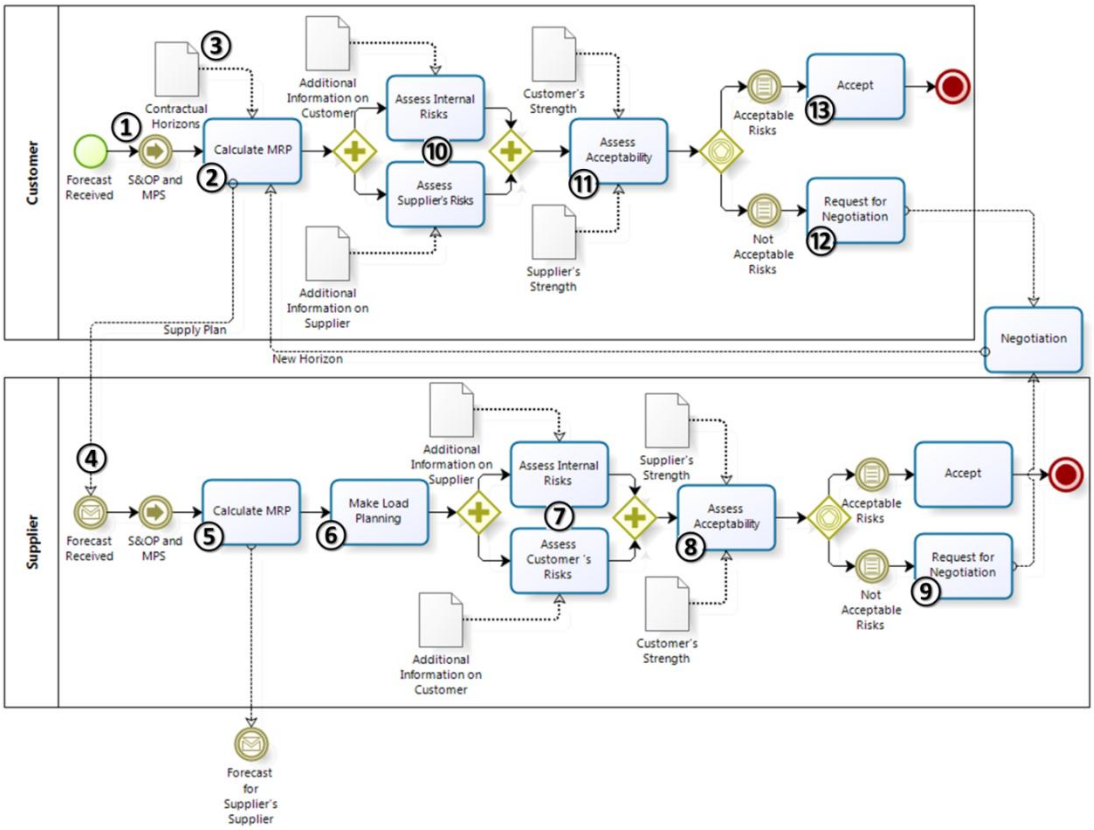

Figure 3.5. Business Process Diagram of period of forecast negotiation

The supply plan is received by the supplier and considered as forecasts (point ④). The supplier makes then his own MRP calculation (point ⑤), with the result of his supply plan (not mentioned in Figure 3.5) and his load planning (point ⑥). Since he has taken into account his cycle time and the cycle time of his suppliers, the supplier is able to see whether this load planning is consistent or not, or in other terms whether he takes too much risks (for instance by ordering parts on the base of the flexible period of forecasts, point ⑦). Depending on the additional information on his customers and suppliers (such as "can they be urged or not? Do they have financial stability or not?"), he decides whether these risks are acceptable or not (point ⑧). If he considers that he takes more risks than his partners (customers and suppliers), he may ask for negotiation (point ⑨).

The customer performs the same evaluation: he makes his assessment of both internal risks and risks he assumes to be on supplier's side (point ⑩). This assessment of course considers the received horizon of the firm period from his own customer, the horizon of the firm period he sends to his supplier, his internal cycle time, his supplier's cycle time, etc. It should also include his opinion on additional information like the cycle time from supplier's suppliers, the real costs of his suppliers, etc. It is clear that this information is only assessed, since it is usually not provided by the supplier, who would not accept to communicate his real costs to his customer.

The risk taken by the customer is in some way proportional to the difference between the horizon he receives and the horizon he sends. It can be different for each of his suppliers, since two different suppliers do not need the same protection, or in other terms do not deserve that the customer takes the same risk (it is for instance acceptable to take risks for protecting a critical supplier, but not a "common" one). Such assessment will provide a customer's vision on the allocation of risks between him and his suppliers.

The next step is to balance the customer's own strength and its supplier's strength and weakness, aiming at assessing the acceptability of the risks he takes (point ⑪). For instance, the customer may consider that he should take lower risks if his supplier has more "strength" than him. Of course, this assessment is very subjective, but is indeed done daily in reality within less formalized processes. If, from customer's vision, risks are not acceptable, he will request for a negotiation process (point ⑫). Otherwise, the customer will accept current plans (point ⑬).

Therefore, three triggers may launch negotiation: request from customer, request from supplier, and request from both customer and supplier. Surely, the visions of risks allocation and acceptability may be opposed at the customer and supplier side, mainly because a company knows his own problems much better than his partners' and may so overestimate them. In any case, sharing real information instead of trying to assess alone the situation of the partner could facilitate to reach a kind of consensus, but would certainly lead to other problems linked for instance to confidentiality.

After the negotiation process, a new agreed horizon will be integrated into customer's MRP plan.

3.1.2 Exchange of information and sequence of activities

Figure 3.5 has provided brief answers to the first two questions: when and where the customer and the supplier need to negotiate on the periods of forecasts. In order to clearly present the activities involved in the negotiation process, as well as for answering the third question, we are going to present in a more formal way the information exchanged and the sequenced negotiation activities, modeled as an UML Sequence Diagram (OMG, 2011). We only focus here on two triggers: request from customer and request from supplier, since the third one is a combination of them.

If the customer's request has triggered the negotiation process, after MRP calculation (1.1 in Figure 3.6) and risks assessment (1.3), the customer sends his request to decrease (or increase) the horizon of firm period to its supplier (1.4) and wait for response.

We shall consider here the case of a demand for decreasing the horizon, since the other situation, favorable to the suppliers, will certainly be immediately accepted. By receiving customer's request, the supplier assesses the new risks he takes, and his extra cost in the contractual horizon (1.4.1). Based on these results, the supplier sends a proposition for a new horizon, which should be shorter than the contractual one (2a), and simultaneously sends additional conditions (2b) which, in his opinion, may compensate his extra cost. This response is considered by the customer who also assesses his risks and his own extra costs (1.5), trying to determine whether the proposed new horizon and additional conditions would satisfy the original intention of risks balancing, as well as the corresponding cost. If the propositions are both satisfactory, the new agreed horizon is chosen. Otherwise, there are two options for the customer:

- *Agree on the new proposed horizon, but suggest new additional conditions which are less favorable for the supplier (3).*

- *Send entirely new propositions if the response from the supplier is far from the customer's expectation, and therefore not acceptable (4).*

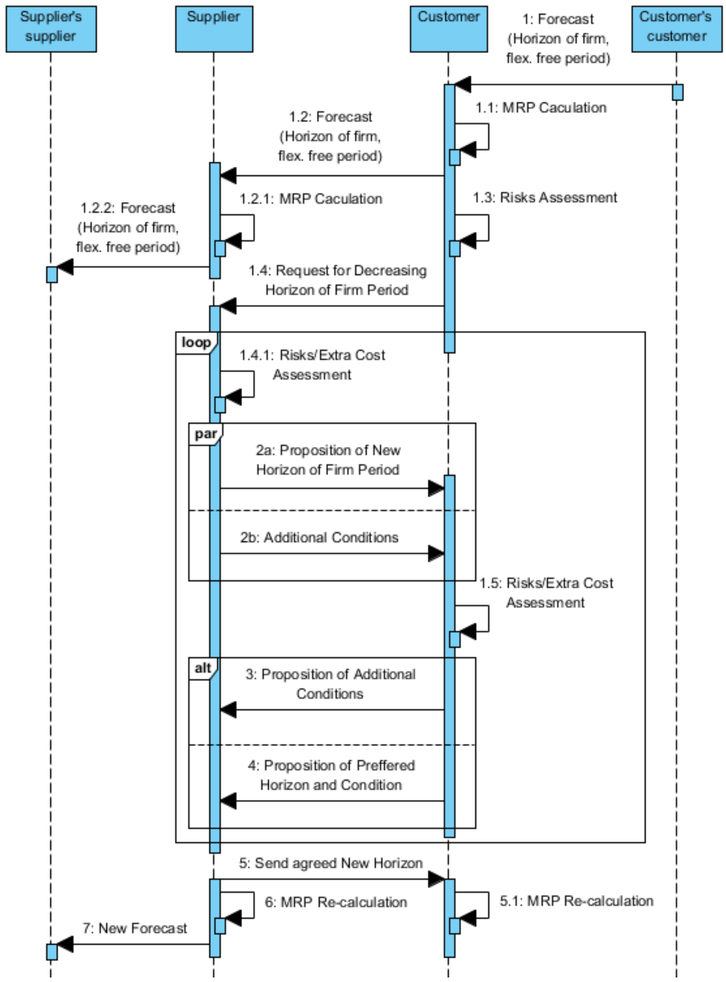

Figure 3.6. Sequence of activities for periods of forecast negotiation (customer requested)

By repeating the loop of assessing risks and extra cost, sending propositions, responding or providing new proposals, the negotiation process continues until the new horizon and additional conditions are agreed by both customer and supplier (5), or stops if no agreement can be found. After negotiation, the new horizon and conditions are applied and new MRP calculations are performed (5.1 and 6). New forecast may be sent to supplier's supplier due to the changes of the periods of forecasts (7). It is clear that Figure 3.6 shows one of the possible scenarios, but not a general negotiation process.

Similarly, the negotiation process launched under demand of the supplier is described in Figure 3.7. In this process, the supplier first sends the request for increasing the firm period (1.2.5). Receiving such request, the customer needs to assess his risks and extra cost (1.2.5.1), then makes his decision on the proposition of a new firm period and the additional conditions (2a and 2b), which is sent back to supplier. After this, the supplier makes his decision on how to answer: accept the proposals, negotiate on the additional conditions (3), or propose a new preferred period and/or additional conditions (4). The loop of negotiation stops as soon as customer and supplier reach a mutual agreement (5), or see that they cannot agree.

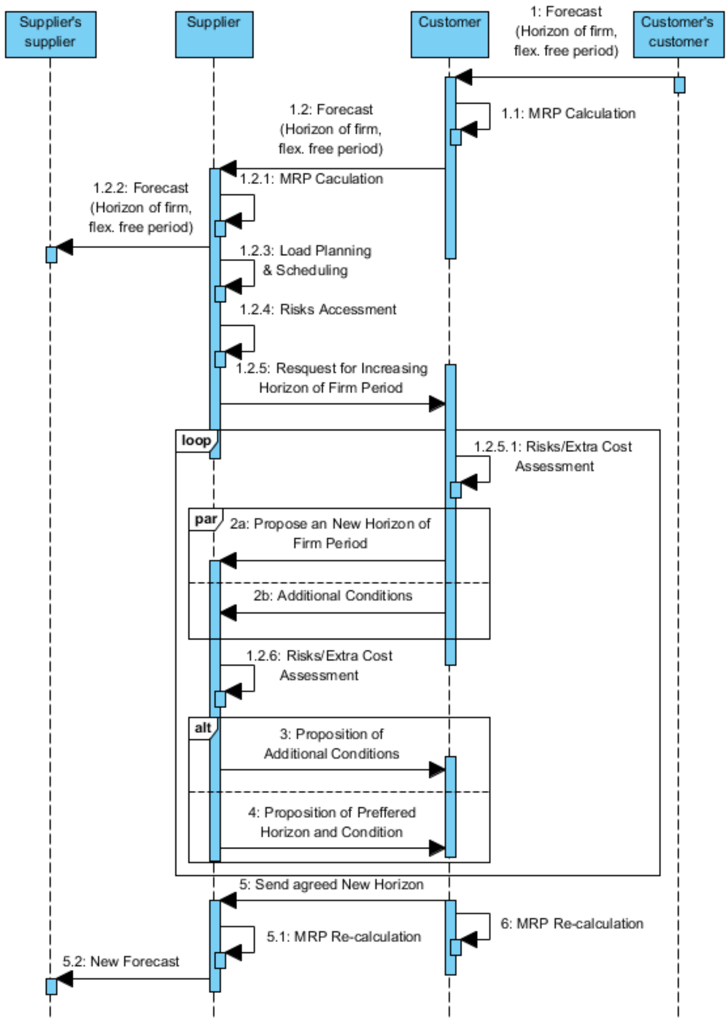

Figure 3.7. Sequence of activities for periods of forecast negotiation (supplier requested)

3.1.3 Extra cost assessment

No matter whether negotiation is triggered by the customer or by the supplier, one of the main activities of the negotiation process is, as already mentioned, to assess the extra costs according to the additional conditions.

On customer's side, it is usually a request for an increased firm period which is received, sent by his supplier. In that case, the customer takes the risk to store parts delivered by the supplier, being unsure to really need them. As a consequence, there is a corresponding extra carrying cost, depending on the confirmation of his own customer's demand.

On supplier's side, a request from the customer asking to decrease the firm period is usually received, with as a possible result the necessity to order raw materials on the base of the flexible periods of forecasts, resulting in increased carrying costs if the flexible demand is not confirmed.

Therefore, customer or supplier should propose additional conditions in order to compensate (at least partially, in a context of risks sharing) these over costs. These additional conditions will usually be in terms of increased/decreased price, but not necessarily. For instance, let us refer to the case mentioned in the interviews where a customer suggested one additional condition: buying back all the cancelled orders over a year (a kind of risk sharing) in order to make his supplier accept the proposition of flexible period of forecast.

Indeed, in the negotiation process, the additional conditions of the proposition may have various forms, depending on the details of the negotiation terms. For example, changing the range of variation in the flexible period is possible in the additional condition. In such case, in order to fulfill the customer's orders in time, especially in the flexible period, extra cost for maintaining a safe inventory inevitably exists. We have summarized the elementary costs which will have to be considered in order to calculate these extra costs in Table 3.1.

Table 3.1. Elements for cost calculation in period of forecast negotiation

Extra Cost	Related elementary costs
Inventory cost	Inventory carrying cost
	Penalty cost
	Purchasing cost

3.2 Negotiation on load variation

3.2.1 Business Process Diagram

On the customer's side, the negotiation on load variation is proposed after the MRP step has been performed (see the top part of Figure 3.8). After integrating the forecasts in the S&OP, then processing the MPS, the customer begins the MRP calculation (point ① in Figure 3.8). The customer may then consider the supply plan for each of his suppliers in order to identify high load variations (by comparing the load for current and previous periods) (point ②). For dealing with high load variation, the flexibility of the mid-term capacity of the supplier is essential. Therefore, the customer has to estimate the mid-term capacity on the supplier's side (point ③), as well as the costs to manage such capacity (point ④). As a consequence, additional information on the supplier's capacity, including internal regular and overtime capacity, external accessible capacity (subcontracting capacity) (point ⑤), and additional information of related costs (point ⑥) are important inputs for this estimation. Again, depending on the closeness of the relationship, this information can be known or estimated.

Based on the estimation results, the customer needs to assess the feasibility of the load variation expected in the current period (point ⑦). From the customer's vision, if the supplier is capable to manage this load variation, the current plan is considered as feasible and the MRP result is accepted (point ⑧). Otherwise, the customer requests for a negotiation process, considering as doubtful the supplier's capability to perform satisfied delivery when facing the considered load variation (point ⑨).

On the supplier's side, the detection of the problem of capacity is not based on estimation, but on the actual capacity/load situation. According to the result of the load planning (point ⑩), the supplier identifies a possible capacity problem (point ⑪) and checks the feasibility (point ⑫) to address this problem (by extra hours or subcontracting in case of increase, by other solutions aiming at decreasing his capacity in case of decrease). Therefore, two important factors have to be taken into account:

- *Price paid by customer (point ⑬)*

- *Cost for extra capacity (or decrease of capacity) (point ⑭).*

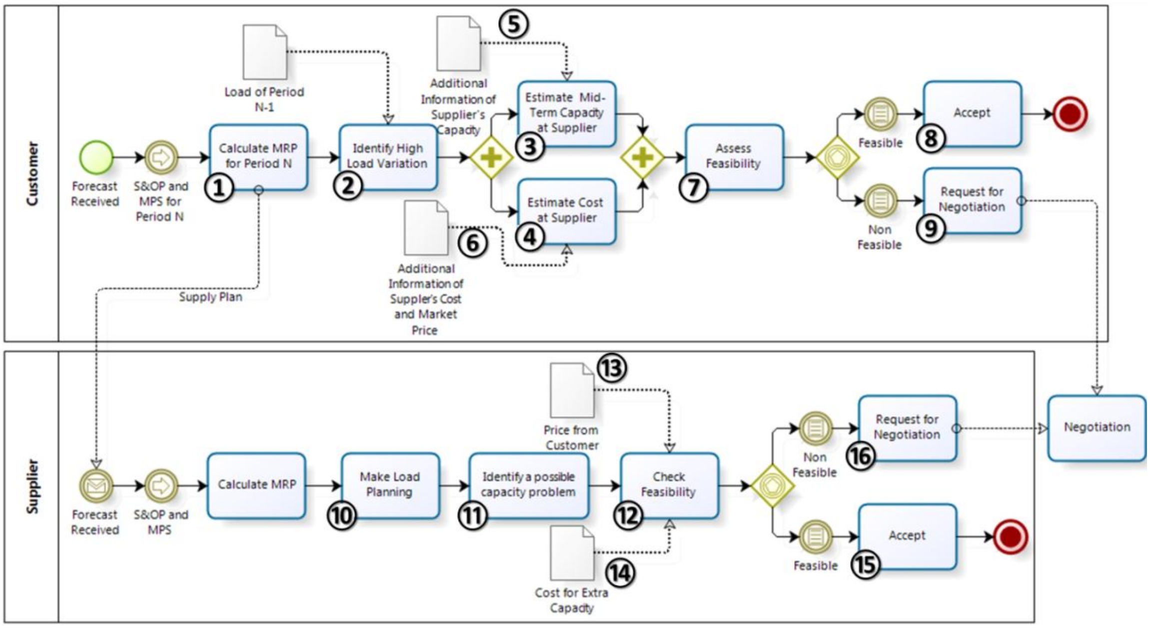

Figure 3.8. Business Process Diagram of load variation negotiation

From the supplier's vision, if the capacity change is considered as feasible, the current plans are accepted (point ⑮). Otherwise, the supplier will request a negotiation process and publish his capacity problems to the customer (point ⑯).

Again, the negotiation process will be triggered either by a customer request, a supplier request or a double request (not considered here). Of course, if the problem is detected by one of the partners, the others have to agree on the fact that there is an actual problem. For instance, a customer may detect a high overload which may have no consequence for a supplier, if other customers of this supplier have decreased their own orders during the same period.

3.2.2 Exchange of information and sequence of activities

In order to better visualize the negotiation on load variation, Figure 3.9 shows a typical scenario of the customer requested negotiation process, modeled as an UML sequence diagram.

After the identification of high load variation (1.3), either increased volume or decreased volume, the customer estimates his supplier's mid-term capacity and related costs (1.4). From the customer's vision, negotiation has to be launched if the supplier might be unable to deal with (high increased load) or would not afford (high decreased load) such high load variation, which would result in poor delivery performance or unvalued costs on supplier side. Therefore, the customer sends to his supplier a request for giving additional information on the problems which may be induced by this high load variation (1.5). After receiving this request, the supplier estimates his extra cost related to the required variation of his capacity (1.5.1), and sends a proposal for a new acceptable load variation and corresponding price, in order to ensure a satisfactory delivery and compensate his internal costs (2a and 2b). Based upon the supplier's proposal, the customer compares his own internal extra cost and the purchasing price proposed by the supplier (1.6). If the customer agrees on the proposal of new load variation and corresponding price, the negotiation process is concluded and an official message of agreement on new variation limits is sent (act 5). Otherwise, there are two possibilities for the customer:

- *Agree on the new load variation but negotiate on the corresponding price (3)*
- *Propose new preferred load variation and price to his supplier (4)*

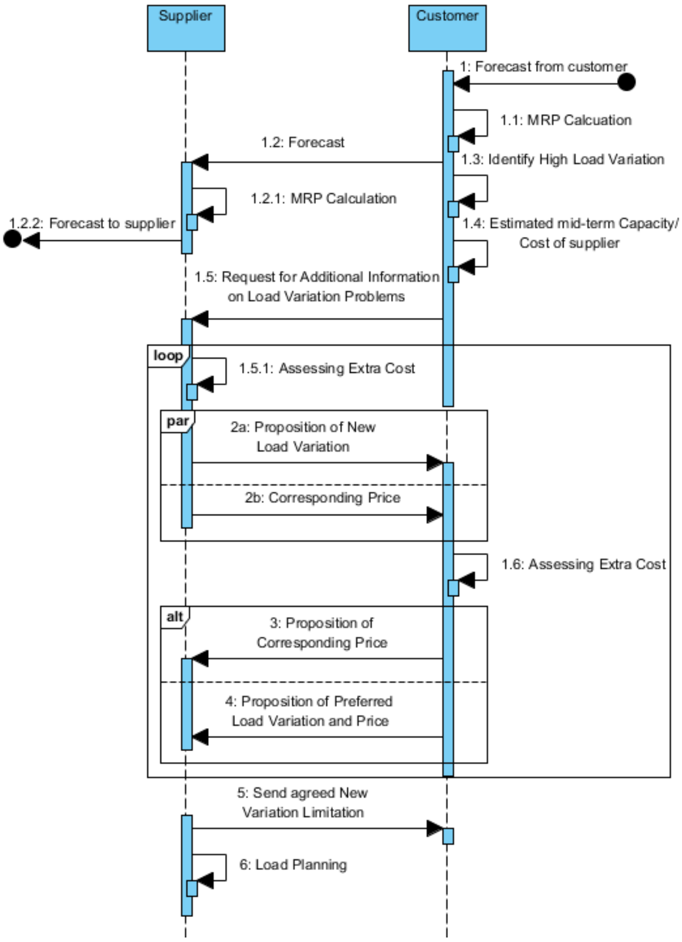

Figure 3.9. Sequence of activities for load variation negotiation (customer requested)

After agreement, a new load planning is performed at supplier's side (6).

Figure 3.10 presents a typical scenario of the supplier requested negotiation on load variation. At supplier's side, the result of the load planning provides a clear vision on the real situation on the total capacity/load allocation (1.2.3). Accordingly, the supplier is able to detect a possible capacity problem based on the capacity assigned to each customer, his purchasing cost and his technical solutions for increasing/decreasing his capacity (1.2.4). Therefore, the supplier sends a request to his customer for modifying the load variation (1.2.5). This request may be either to decrease load variation or increase it, in case of lack of load. After having received the request from the supplier, the customer assesses his extra cost and current purchasing price (1.3) then sends his proposal for a new load variation and corresponding price, also taking into account his own commitments and the orders slack time (2a and 2b). After receiving the customer's proposition, the supplier also needs to estimate his extra cost (1.2.6). As in the previous situation, the price may also be negotiated together with the volume of the variation.

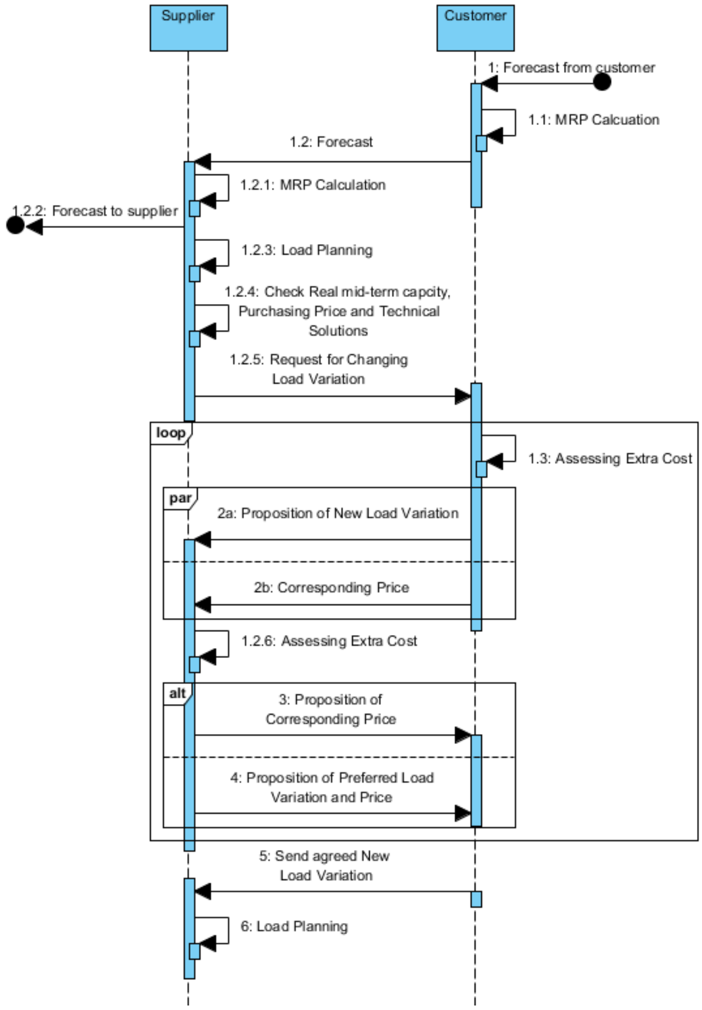

Figure 3.10. Sequence of activities for load variation negotiation (supplier requested)

If the supplier accepts the customer's proposition, the negotiation is over (5). Otherwise, two options may be possible:

- *The supplier agrees with the new load variation but wants to negotiate the corresponding price (4)*
- *The supplier proposes a new preferred load variation and price (5)*

When the new load is known, a load planning is launched at the supplier's side (6).

Since the double requested negotiation process is the merged process of the two described ones, we do not provide more precise description for this case here.

3.2.3 Extra cost assessment

During the negotiation of the load variation, the variables taken into account for extra cost assessment are different for the customer and the supplier, since load variation leads to problems of capacity at supplier's side whereas they are linked with inventory levels at customer's side.

At the customer's side, the load variation is directly related with the required purchasing quantities in the current period. Nevertheless, the customer usually keeps a slack time between his own deliveries and the required delivery time sent to his supplier (in addition to his internal cycle time). Therefore, a part of the required load variation (in case of increase) may be absorbed by this slack time, under condition that the customer accepts this risk. In a sense, he gives his own slack time to his supplier in this case. Indeed, it seems quite rare that the customer delays his own production process in order to help his supplier to overcome capacity problems if other choices are possible. If the load variation is required for allowing an on time delivery of the customer, increasing the purchasing price can be a solution in order to avoid delays. Therefore, in the proposed negotiation process, we consider that the load variation on customer side mainly influences his inventory level and his purchasing costs (see left part of Table 3.2).

Table 3.2. Elements for cost calculation in load variation negotiation

Customer Side	Supplier Side
Extra Cost	**Extra Cost**
Cost of Inventory Variation	Cost for Capacity Variation
Related Variable	**Related Variable**
Inventory carrying cost	Regular capacity cost
Penalty cost	Overtime capacity cost
Purchasing price	Subcontracting capacity cost
	Sales price

At the supplier's side, in case of high increase, the supplier may not be able to handle and adjust his capacity without extra cost (extra hours or hiring of temporary workers should be more expensive than the normal internal capacity). External capacity can also be found through subcontracting or outsourcing, again with a higher cost than the use of the normal internal capacity. On the other hand, in case of load decrease, the supplier must still pay internal fixed costs, such as labor employment, machine maintenance, etc. but earns less revenue from his sales (unless this load decrease in compensated by other customers). Therefore, the assessment of the link between capacity and load at supplier's side is based on various factors, as shown in the right part of Table 3.2 (fixed costs, internal costs for increasing capacity, external costs, etc.). Figure 3.11 considers linear relationships, but steps may be present in various areas of the figure, for instance, when hiring new workers or using a new shift. The left part of the curve only suggests that not using the full capacity may increase the cost per manufactured part.

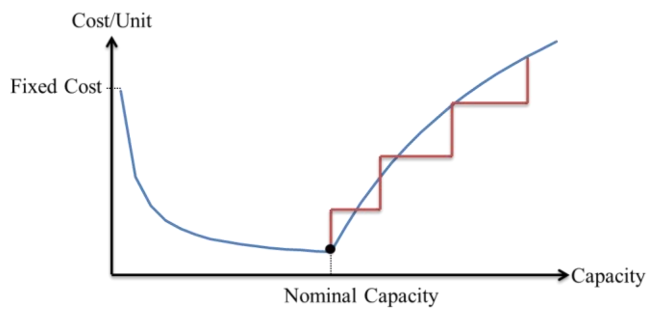

Figure 3.11. Example of cost curve of capacity

3.3 Negotiation on price and cycle time

3.3.1 Business Process Diagram

The negotiation on price and cycle time is considered here for a small number of urgent orders, see Figure 3.12. At the customer's side, MRP calculation is based on S&OP and MPS, also taking into account the urgent orders sent by customer's customer (point ① of Figure 3.12), at the level consistent with their degree of anticipation. The results of the MRP step will provide a clear view on the material requirements induced by these urgent orders to the supplier (point ②): they may have no effects on the current supply plan, or urgent material orders may be necessary. After load planning, the required due dates of the materials are confirmed (point ③), then the customer needs to estimate the feasibility of urgent orders on supplier's side (point ④), as well as the possible extra cost for the supplier (point ⑤). According to customer's vision, if the urgent orders are considered as feasible, meaning that the supplier is supposed to be capable to deal with such urgency, the current plan is accepted (point ⑥) and the urgent orders are sent to the supplier (point ⑦). Otherwise, if the customer thinks that his supplier is not able to deal with these urgent orders (based on customer's estimation), negotiation is requested (point ⑧).

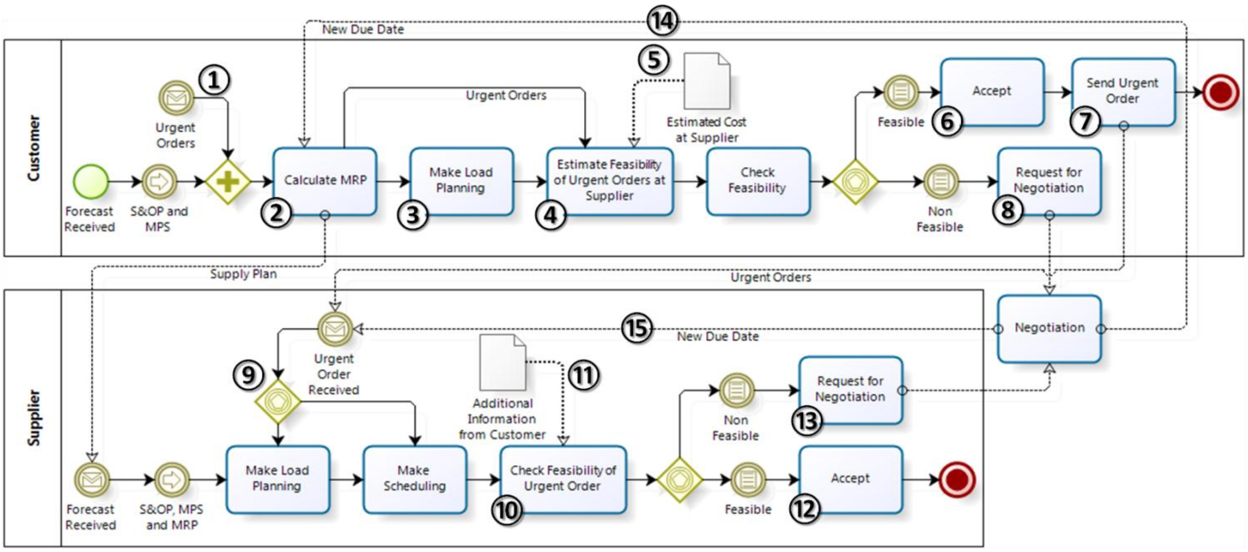

Figure 3.12. Business Process Diagram for price and cycle time negotiation

At the supplier's side, the urgent orders usually arrive at the load planning or detailed scheduling levels (point ⑨). Based on the allocation of capacity/load towards each customer, the supplier needs to check whether it is feasible to deliver the urgent order(s) (point ⑩) in the conditions required by the customer (including price) (point ⑪). If the actual situation allows the supplier to adjust his capacity/load for fulfilling the urgent orders, the current plan is acceptable and the production process is launched (point ⑫). Otherwise, the supplier sends a request for negotiation (point ⑬), and notifies his customer that delivery as required is questionable in the present situation.

Therefore, the negotiation on price and cycle time of urgent orders is launched by three possible triggers: customer request, supplier request and double request from both customer and supplier. After negotiation on the urgent orders, the new agreed due date will be integrated in both customer and supplier's plans (point ⑭, ⑮).

3.3.2 Exchange of information and sequenced activities

Figure 3.13 shows a typical scenario for customer requested negotiation on price and cycle time.

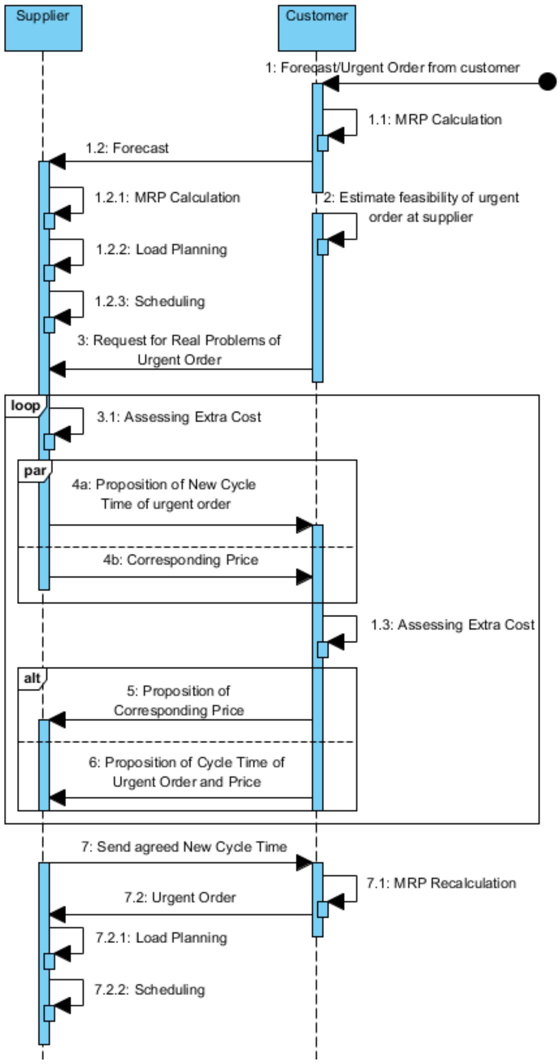

Figure 3.13. Sequence of activities for price and cycle time negotiation (customer requested)

If the customer has a doubt on the supplier's capability of dealing with the urgent orders, he requests a negotiation (3), including a request for additional information on the real problems induced by the urgency. The request from the customer will lead to the supplier's assessment of the possible extra cost linked to this urgency (3.1). According to the real capability to fulfill the customer's urgent order, the supplier sends a response, including eventually the proposition of new cycle times for the urgent order(s) and the corresponding price(s) (4a and 4b). Receiving the answer from the supplier, the customer calculates his own extra cost (1.3), checking whether the proposed cycle time(s) is consistent with his actual requirement, and if it is still beneficial to purchase at the proposed price. If the proposal from the supplier is acceptable, the negotiation process is finished (7). Otherwise, the customer has two options:

- *Accept the new cycle time (if the proposed cycle time is consistent with what he expects) but not the corresponding price (5),*
- *Propose new preferred new cycle time and price (6).*

The loop of proposal/answer is continuing until customer and supplier reach mutual agreements on the cycle time and on the corresponding price (7), or see that there cannot by any agreement. When negotiation is over, the new characteristics of the urgent orders are integrated in the planning of both customer and supplier (7.1 and 7.2.1/7.2.2).

The supplier's requested negotiation of price and cycle time is launched when the supplier doubts to be able to fulfill the customer's urgent orders. Figure 3.14 presents a typical scenario for this negotiation.

The results of the load planning and scheduling provide the supplier with information on the actual allocation of capacity towards his different customers (1.3.3). Accordingly, the supplier is aware of his capability to satisfy customer's urgent requirements. Therefore, a request for increasing the cycle time or purchasing price of urgent order may be sent to the customer (1.3.4), stating that the current required cycle time is not feasible at supplier's side. After receiving the request from the supplier, the customer assesses his extra cost based on the real requirements of the urgency and on the corresponding purchasing price (1.4). If there are slack times between his own delivery due dates and the delivery time from his supplier, the customer may increase the required cycle time in order to avoid a higher purchasing price. Otherwise, increasing the price could be necessary to compensate the supplier's over costs for adjusting his internal capacity and ensuring on-time delivery as required by the customer. Therefore, the results of the internal assessment allow the customer to answer to the supplier's request through a proposition of new cycle time and corresponding price (2a and 2b). According to the customer's proposal, an assessment of the extra cost at the supplier's, mainly concerning the cost for additional capacity required by the urgency and customer's proposed price, is also performed (1.3.5). Afterwards, if the supplier considers that the proposed cycle time and corresponding price are acceptable, negotiation is closed by the supplier's agreement. Otherwise, the supplier proposes a new price to the customer (3), or sends a new proposition on preferred cycle time and price (act 4). Negotiation is going on until customer and supplier agree on both the required cycle time of the urgent orders and the corresponding price. After the negotiation, the customer sends a formal agreement response to the supplier's request (5) and the new cycle time is integrated in the supplier's load planning and scheduling, as well as in the customer's MRP (7 and 6/8).

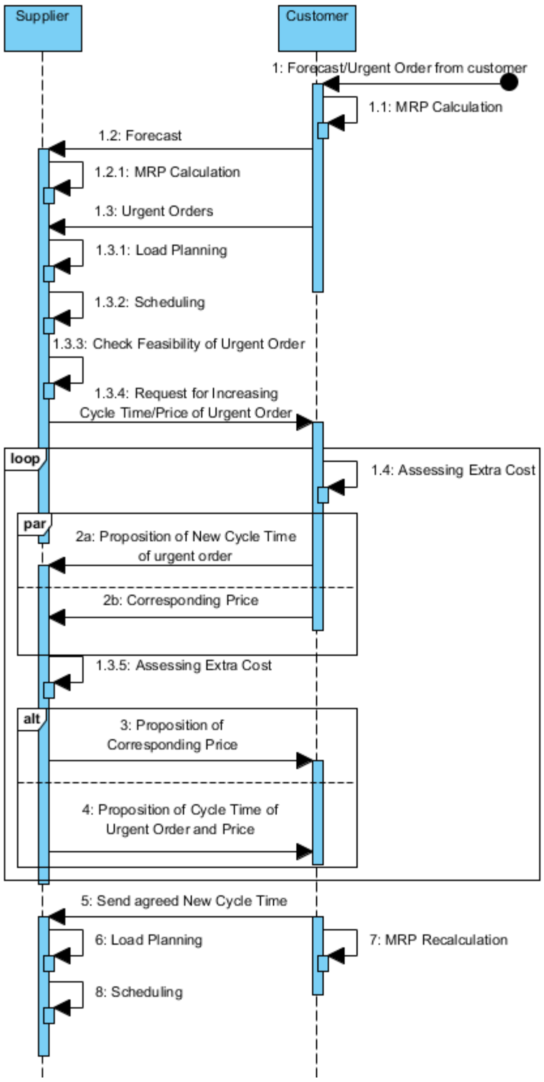

Figure 3.14. Sequence of activities for price and cycle time negotiation (supplier requested)

3.3.3 Extra cost assessment

At the supplier's side, the extra costs are mainly concerning the possible increase of capacity required by the processing of the urgent orders, and eventually a cost for re-planning. As we mentioned in the negotiation process on load variation, the cost for increasing capacity is not a linear variation of the load volume (see Figure 3.11 in section 3.3.2). Finding extra capacity, either internally or externally, induces over costs which may sometimes vary in a discrete way. In order to satisfy the urgent orders, the customer's purchasing price should then increase. Therefore, the main variables in extra cost assessment are listed in the right part of Table 3.3.

At the customer's side, the changes on the required delivery time depend on the slack time kept by the customer. There are two possibilities for assessing extra costs (see left part of Table 3.3):

- *The due date is mandatory, and an agreement has to be found on the price,*
- *The due date can be negotiated, resulting in a lower increase of the price.*

Table 3.3. Elements for cost calculation in price and cycle time negotiation

Customer Side	Supplier Side
Extra Cost	**Extra Cost**
Cost for Managing Urgency	Cost for Capacity Increase
Related Elementary Costs	**Related Elementary Costs**
Penalty cost	Regular capacity cost
Purchasing price	Overtime capacity cost
	Subcontracting capacity cost
	Sales price

3.4 Negotiation on orders priorities and lot sizes

3.4.1 Business Process Diagram

The negotiation on orders priority and lot sizes occurs at the operational levels, and is mainly related to constraints on capacity or cost (see Figure 3.15). At the customer's side, depending on the lot sizing policy, the lot size is either an input (for instance, if an economical lot size has been defined) (point ①) or a result (if a lot-for-lot policy is used) (point ②). The customer may in the last case need to check whether the supplier's constraints on lot sizes are consistent with his actual requirements (point ③). If, from the customer's point of view, there is no possible problem, the current MRP calculation is acceptable and a load planning and detailed scheduling can be performed (point ④, ⑤). If the customer considers that the current lot size is not feasible, due to the constraints of the supplier, a request for negotiation on lot size will be sent (point ⑥).

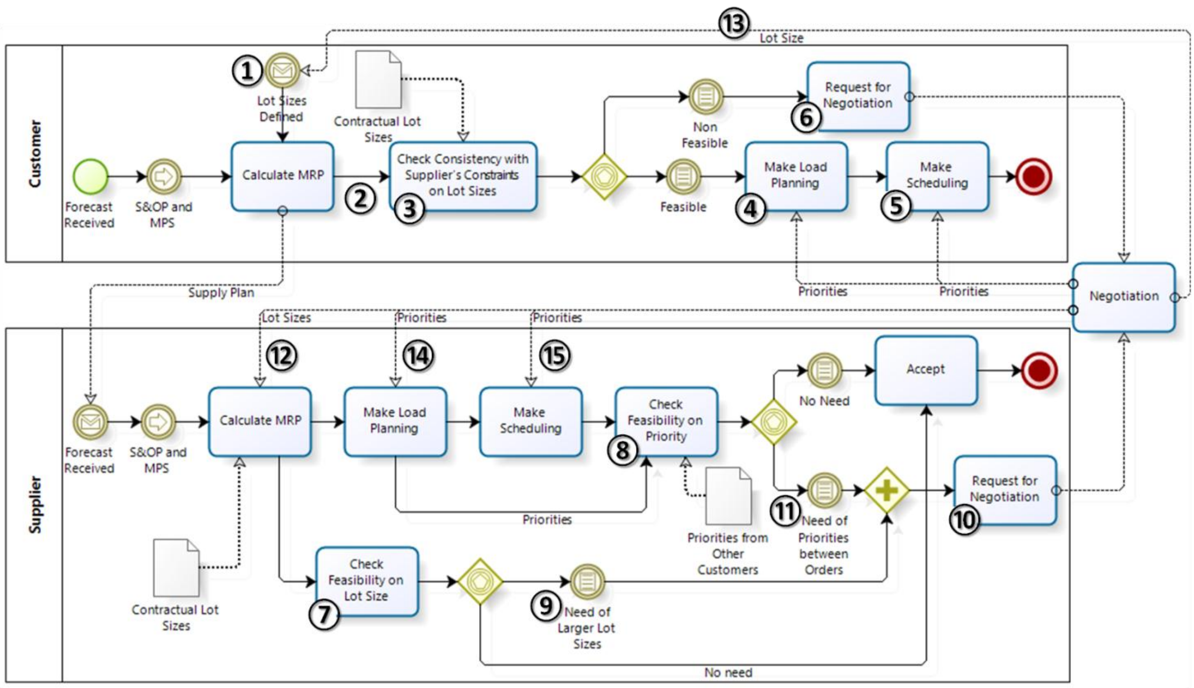

Figure 3.15. Business Process Diagram of order priorities and lot sizes negotiations

At the supplier's side, there are two major tasks: one is to check the feasibility on lot sizes based on the results of the MRP calculation (point ⑦); the other is to check the respect of the due dates based on the load planning and detailed scheduling (point ⑧).

In order to reduce the frequency of the set-ups, the suppliers usually regroup orders of similar parts coming from a single or eventually from different customers. As a consequence, the real production lot size may be larger than the contractual one with one customer, which may be necessary to meet acceptable prices. As seen during the interviews, these internal adjustments might occasionally result in early or delay deliveries. Therefore, if the supplier considers that increasing the current contractual lot size could possibly lead to some benefits (point ⑨), a request for negotiation on lot sizes can be sent to the customer (point ⑩).

Similarly, if meeting all the due dates of the orders in process is not possible, and instead of defining internal priorities linked to the importance of each customer (point ⑪), the supplier can ask for a negotiation on the real priorities of the orders (point ⑩), which would allow him to define a schedule possibly acceptable by all the customers.

The negotiation process on lot sizes is either launched by the customer's request, supplier's request or both, while problems on orders priorities are detected by the supplier. The corresponding negotiation process may so only be launched upon supplier's request.

After the negotiation process, the new agreed lot sizes will be integrated into the MRP calculation of both customer and supplier (points ⑫, ⑬), and the order priorities will be entered into the load planning and scheduling (points ⑭, ⑮). It can be noticed that these two negotiations are quite different from the previous ones, since they may involve several customers at the same time, and would so be certainly more difficult to handle in practice.

3.4.2 Exchange of information and sequence of activities

Figure 3.16 shows a typical scenario of customer requested negotiation process on lot sizes, using a sequence diagram.

The customer requested negotiation on lot size is based on customer's vision of supplier's constraints for dealing with the current lot sizes. Therefore, if the customer detects a possible problem, he sends a request to his supplier, asking his confirmation on the problems on lot sizes (1.5). After receiving the request from the customer, the supplier assesses his extra costs and suggests a feasible lot size and the corresponding price, based on a compromise between his own constraints and those of his customer (1.5.1). Then, the supplier sends a proposal to his customer, possibly including a new larger lot sizes and the corresponding (lower) price (2a, 2b). According to the supplier's proposal, the customer checks the feasibility of the suggested lot size and assesses his related extra costs (1.6). If the customer agrees on the supplier's proposal, the negotiation process is finished (5). Otherwise, the customer may accept the new lot sizes but negotiate the corresponding price (3). He may also propose both a preferred new lot size and price to his supplier (4). The loop continues until the customer and the supplier reach an agreement on the new lot size and on the corresponding price (or verify that no agreement is possible). Recalculation of the MRP step is performed by the supplier and customer with the new lot size (6 and 5.1).

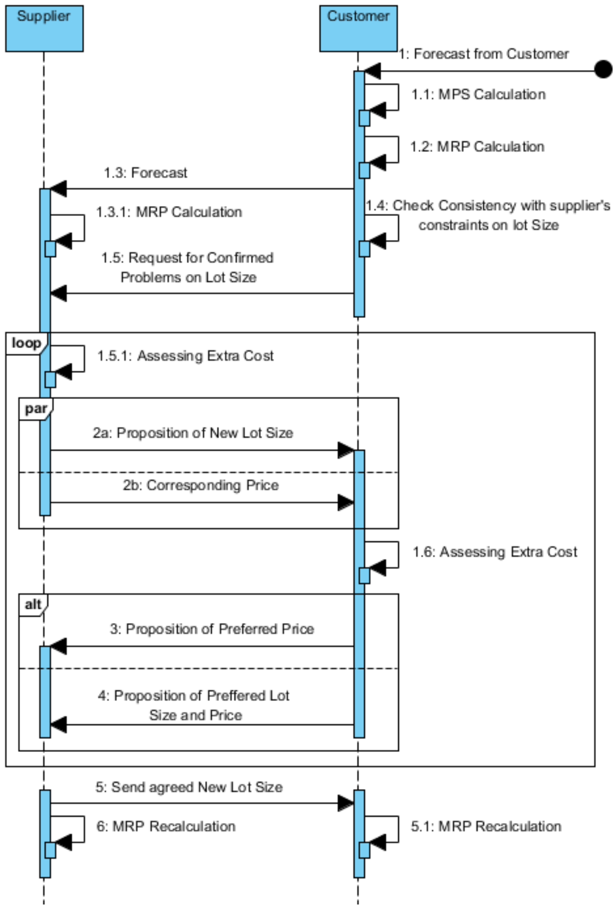

Figure 3.16. Sequence of activities on lot size negotiation (customer requested)

Figure 3.17 describes the scenario dealing with supplier requested negotiation on lot sizes. At the supplier's side, the negotiation process is triggered by real operational constraints aiming at decreasing the production costs. According to the results of order regrouping in the MRP calculation, the supplier may verify whether he may get acceptable lot sizes while meeting the due dates of the orders. If not, he may send a request to his customer, demanding larger lot sizes, in order to overcome his local constraints (1.3.3). As already discussed, he may also ask for new priorities between orders for solving the problem locally, which will be detailed later on.

After receiving this request, the customer needs to assess the extra cost due to the increase of lot sizes, which will again result in an increased inventory or in problems for meeting his own due dates (1.3.3.1). The customer then sends a proposition of new lot size, and a new purchasing price which would compensate his extra cost (2a, 2b). From this proposal, the supplier is able to check whether the new lot sizes are acceptable according to his local constraints, as well as whether it is beneficial to accept the corresponding price (1.3.4). If it is acceptable, the negotiation process is terminated (5). Otherwise, the supplier may accept the proposal on lot sizes but continue to negotiate the purchasing price (3), or may send an entirely new proposition on lot sizes and price (4). When the agreement is reached, the new lot size will be integrated into the MRP by the supplier and by the customer (5.1 and 6).

Unlike the other items, the negotiation on order priority is only triggered by a request from the supplier, since the problem of priority is detected at the supplier's side when he discovers that he cannot meet the due dates for some of the orders in progress. Let us precise that the problem can have external causes (machine failures, etc.) but can also be linked to the aspects under negotiation previously described (grouping for meeting a lot size, urgent orders, load variation, etc.). In that case, this negotiation process could be called as a partial solution to a previously described problem.

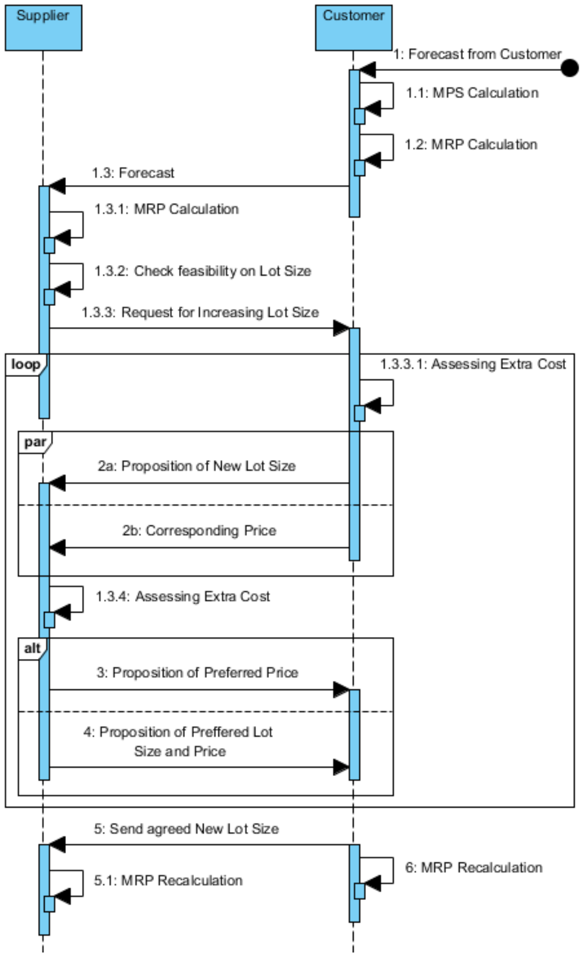

Figure 3.17. Sequence of activities on lot size negotiation (supplier requested)

Figure 3.18 shows a typical scenario for order priority negotiation, including both early and delayed delivery.

In case of estimated late delivery or early one related to grouping orders, the supplier sends a message to his customer(s), informing him (them) on the current situation (1.2.4 and 4).

The problem of late deliveries can be solved thanks to an increase of the capacity, which refers to the negotiation process on load variation already described. We shall focus here on the second solution of a load/capacity balance problem, which is to move the load, and so to possibly postpone some orders. As stated earlier, the problem may be solved at the level of a single customer, but may also concern several customers in case of important overload.

Concerning delayed delivery, the supplier will ask his customer for elements allowing him to assess the priorities of the orders (1.2.4). Since it can be necessary to compare the priorities of several customers, numerical priority levels as they are sometimes used in scheduling can hardly be considered (the semantics attached to a priority level, for instance denoted by a number, may be very different from one customer to another). According to the situations, elements such as the slack time, inventory levels, or criticality of the parts could be considered. In order to define this "priority", the customer will have to assess the possible extra costs (1.2.4.1) due to a late delivery and will provide order priorities under various forms (2a). These extra costs may include changes of the shipping price, depending on a shipping policy. They can be transmitted to the supplier as additional conditions (2b), which can be negotiated if the supplier considers them as not acceptable (3), based on his own costs (1.2.5).

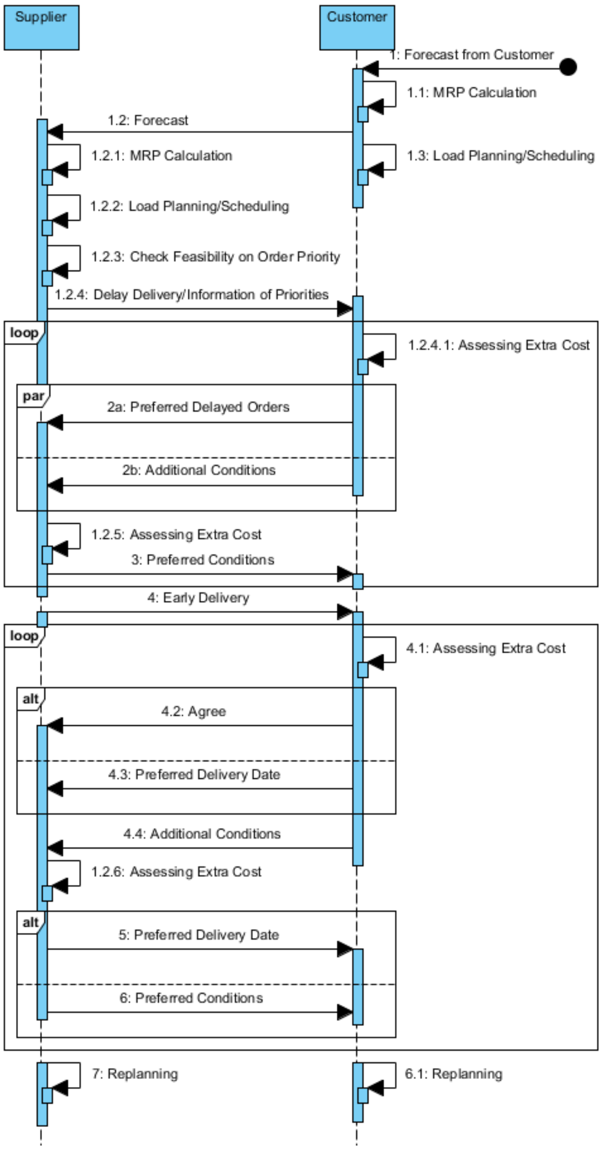

Figure 3.18. Sequence of activities of order priority negotiation

Similarly, the supplier might send a message related to early delivery to his customer (3). In this case, the customer sends his agreement (4.2) or not (4.3) on the delivery date and its additional conditions (4.4). These conditions are again based on an assessment of his extra costs (4.1) linked to the early delivery (inventory and risks taken if the corresponding orders are not confirmed by his own customers). The supplier may then make other proposals either on the delivery date (5) or on the additional conditions (6) according to his extra cost assessment (1.2.6). After the negotiation of order priority, re-planning is necessary at both supplier and customer's side (7 and 6.1).

3.4.3 Extra cost assessment

At the supplier's side, a so called "optimal" manufacturing lot size is still often defined, depending on the set-up costs and inventory carrying cost (see for instance Wilson's formula (Camisullis and Giard, 2008)). Nevertheless, it is now a widely accepted idea that the blind use of such formula may lead to increased lot sizes, and as a consequence increased cycle times, which are critical in a context characterized by demand uncertainty and need for flexibility. Therefore, limiting the work in progress is a policy often promoted by large companies. For instance, the lot size can be the quantity required by period (lot-for-lot) or the result of the grouping of the requirements on a maximum (low) number of periods. In that case, the companies then launch projects aiming at decreasing set-ups for making such policies acceptable. Nevertheless, many small companies have very basic operational problems, and still use the concept of economical quantities.

At the customer's side, the purchasing lot size of the components depends on the delivery cost and inventory carrying cost. Indeed, deliveries in large quantities may be less expensive, but this is seldom the case in the aeronautic industry, quantities being relatively low and unitary prices, and consequently carrying costs, high. Therefore, customers in the aeronautic industry usually promote the idea of small lot sizes, even if they have to take into account the technical constraints of their suppliers.

Therefore, the elements allowing to calculate extra costs are listed in Table 3.4, showing our primary considerations in lot sizes extra cost assessment, among which, transport cost, back order cost and purchasing/sale price.

Table 3.4. Elements for cost calculation in order priorities and lot sizes negotiation

Customer Side	Supplier Side
Extra Cost	**Extra Cost**
Cost for Increased Lot sizes	Cost for Decreased lot sizes
Related Elementary Costs	**Related Elementary Costs**
Inventory carrying cost	Inventory carrying cost
Penalty cost	Set-up cost
Material cost	Material transportation cost
Material transportation cost	Penalty cost
Purchasing cost	Sales Price

3.5 Synthesis

So far, the negotiation processes we suggest as an illustration deal with four major, but not completely independent, items: periods of forecast, load variation, prices and cycle time, order priority and lot sizes. The main idea was to explain how to turn these characteristics, usually fixed by contract, into negotiable ones.

The suggested negotiation processes have of course been defined based on practices identified in the case studies. These practices were often hidden, and had sometimes quite questionable results. The idea has been to consider them not as negative practices to remove, but as signs that some basic needs of the partners were not enough taken into account in the cooperation process. Therefore, our aim has been to turn them into official practices by including them into a negotiation process, trying to keep their positive aspects while decreasing their drawbacks.

We have detailed each negotiation item, including when, where and how these negotiation processes could be performed. Some basic considerations on how to assess the corresponding costs have been given as examples. It will then be required to check whether this negotiation, in spite of its oddity compared to present industrial habits, could lead to a win-win situation. This will be done in the next chapter through some simple illustrations.

Even from the common sense, the suggested negotiation processes are clearly not realistic in many situations. For instance, it is obvious that a customer accepting that his prices could be constantly modified according to the situation would spend more time in negotiation with his supplier than possibly acceptable. Similarly, it is true that a balanced negotiation requires an equal power of the partners which is seldom the case in reality. In spite of this, we have decided to make some simple simulations in order to show that these negotiations could bring to improvements in some cases. Furthermore, we shall investigate with more details the conditions for making such negotiations possible.

4 Conclusion of chapter 3

In the chapter, the negotiation processes we suggest deal with four major items: periods of forecast, load variation, prices and cycle time, and order priority and lot sizes. The main idea of the negotiation processes would be to turn these characteristics, usually fixed by contract, into negotiable ones. Our primary intention is to publish the hidden, blind constraints and problems through negotiation processes, helping supply chain members to cooperate with each other in a more open way.

From a global point of view, we have seen that extra costs and payment were to be balanced during the negotiation process. Therefore, we defined the specified activities and some considerations for assessing extra costs during the suggested negotiation process using business process models and sequence diagrams. These models have clearly showed where, when and what we need to perform these negotiation processes.

So far, the suggested negotiation processes have been described, but only on a theoretical base. Therefore, we are going to illustrate these proposals, as well as the cost related constraints, through numerical examples, in chapter 4.

In addition, we have seen that the suggested negotiation process would benefit from an exchange of information on some critical aspects, like real lead times and real costs, which is highly dependent on the level of trust between partners. Therefore, qualitative aspects related to the type of relationship between customer and supplier will be investigated in Chapter 5.

Chapter 4
Cost Assessment during the Negotiation Process

In chapter 3, the suggested negotiation processes have been introduced, including issues regarding the assessment of the extra costs between customer and supplier. These suggestions aim at discussing some problems which are often hidden in the supply and demand process, by turning some of the contractual items into negotiable ones, which allows the supply chain members to suggest adjustments based on their real situations. The assessment of the extra costs, allowing cost/benefit and risk sharing between partners, is one of the main requirements for making this negotiation possible. Therefore, in this chapter, we are going to illustrate within a simplified but realistic framework how to calculate the various costs in the supply and demand process; we shall then show the possible interest of negotiation by comparing classical cases with the situation after the negotiation process. These simulations aim at helping to identify the practical situations in which the suggested negotiation process could be of interest.

1. Simplified cost model

1.1. Bases of the model

In the considered simplified model, we have tried to summarize the different costs present in the supply and demand process. The objective of this cost assessment framework is to illustrate how such model can be the main support of the negotiation process. In that purpose, we have tried to consider the various components of the total cost, even if the way each cost is calculated is of course a simplification of reality. We consider here costs linked to procurement, production and delivery in a supply chain, the final goal being to decrease the total cost of the entire chain while balancing the risk and cost between partners. The considered costs are summarized in Figure 4.1.

In the model, we consider without loss of generalization that the buyer (customer) pays for the transportation of the goods (considering other solutions do not set into question the consistence of the framework). So, a supply chain member buys components/materials from his suppliers, pays the material cost and transportation cost and stores the components into material (components) inventories before releasing production orders. As a consequence, purchasing costs include here the costs of the materials, of the transportation and of the inventories of raw materials/components (see Figure 4.1). If the supplier's delivery is delayed, a penalty cost may be charged on this supplier, which decreases the purchasing cost of the customer.

Considering the items which have to be negotiated (see Chapter 3), it is important to include issues related to lot sizes and resource capacity in the production cost model. Nevertheless, we do not need here a real model of production costs. Therefore, we have decided to implicitly model the production system of a company as a single work center for each finished product, and to describe a product with a simplified bill of materials: only one component is required for obtaining a finished product after a single operation on a work center. The internal production costs then include the cost linked to the capacity of the used work center (using regular or extra-hours) or linked to sub-contracting, as well as set-up costs and finished product inventory carrying costs (see Figure 4.1). Penalty costs for delayed delivery (shortage) towards the customer may also be included, due by the manufacturer.

Each supply chain member, either supplier or customer, has the same total cost structure: purchasing costs and production costs, plus benefit, is equal to the sales revenue.

Of course, it is a simple and basic cost structure, which is not sufficient to represent the entire cost system in a supply chain, but it is in our opinion realistic enough for illustrating our suggestions regarding the negotiation process. As it will be seen, the principle of the negotiation process remains valid if more realistic costs are used.

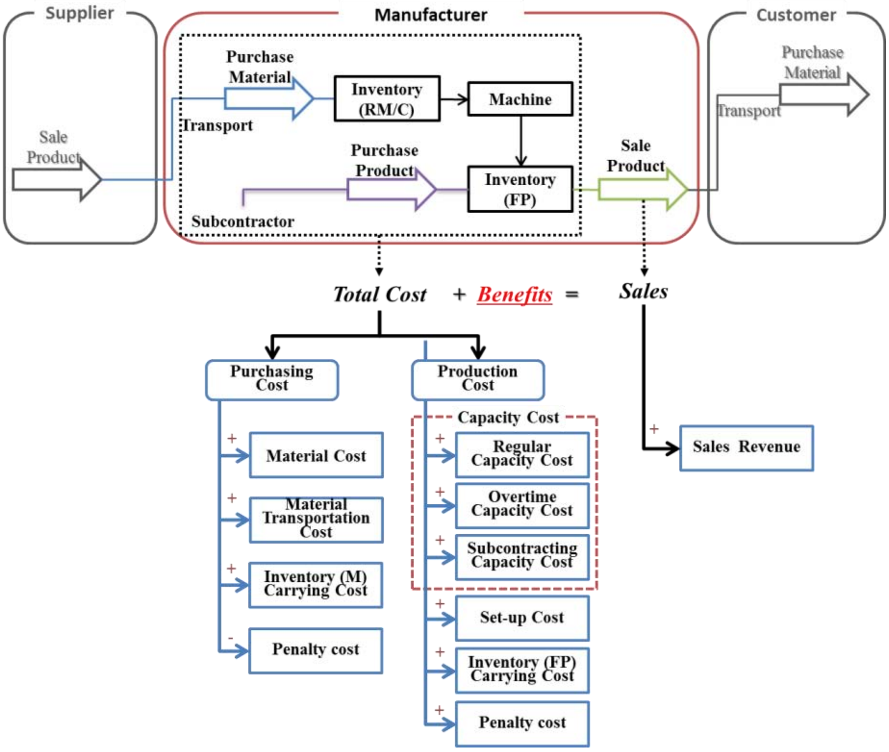

Figure 4.1. Suggested structure of total cost

1.2. Notations

Let us consider the following notations:

➢ *Sets of entities*

- $\{c\}$: Set of customers
- $\{p\}$: Set of finished products
- $\{m\}$: Set of component/material purchased from suppliers
- $\{t\}$: Set of periods of the horizon $\{t\}=\{1, 2,\ldots, T\}$
- $\{i\}$: Set of periods in which the purchased material should be delivered from supplier as required, and/or finished product should be delivered towards customers $\{i\} \subseteq \{t\}$.

➢ *Parameters of quantities*

Q_p^t: Quantity of the finished product p produced with the regular capacity in period t

O_p^t: Quantity of the finished product p produced with the overtime capacity in period t

A_p^t: Quantity of the finished product p purchased from subcontractor in period t

${}_{c\ p}^{t\ i}$: Quantity of the finished product p delivered to the customer c in period t, which should have been delivered in period i

$S_m^{t\ i}$: Quantity of the component/material m purchased from supplier, delivered in period t, which should have been delivered in period i

${}_p^t$: Quantity of finished product p in the finished product inventory at the end of period t

${}_m^t$: Quantity of component/material m in the component/material inventory at the end of period t

MO_p: Maximum number of product p which can be produced with overtime capacity by period

➢ *Parameters of price and cost*

PP_m: Purchasing price of one unit of component/material m from supplier

$SP_{c\ p}$: Sale price of one unit of finished product p to the customer c

$S\ _p$: Penalty cost for shortage of one unit of finished product p in one period

$S\ _m$: Penalty cost for shortage of one unit of component/material m in one period

$R\ _p$: Unitary cost of using the regular capacity to produce finished product p

${}_p$: Unitary cost of using the overtime capacity to produce finished product p

$P\ _p$: Price of purchasing one unit of finished product p from subcontractor

$T\ _m$: Cost for one transportation (independent from the quantity) for component/ material m from supplier

$T\ _m$: Cost to transport one unit of component/material m from supplier

ST_p: Set-up cost to produce one lot of the finished product p

➢ *Functions*

$MR_m(t)$: Material cost of component/material m from supplier in period t

$MT_m(t)$: Material transportation cost of component/material m from supplier in period t

$M\ _m(t)$: Material inventory carrying cost of component/material m in period t

$MP_m(t)$: Material penalty cost (paid by supplier) of component/material m purchased in period t

$PH_m(t)$: Purchasing cost of component/material m in period t

$PR_p(t)$: Regular capacity cost to produce the finished product p in period t

$PO_p(t)$: Overtime capacity cost to produce the finished product p in period t

$PS_p(t)$: Subcontracting cost to purchase finished product p in period t

$S\ _p(t)$: Set-up cost to produce finished product p in period t

$P\ _p(t)$: Product inventory carrying cost of finished product p in period t

$P\ _p(t)$: Product penalty cost of finished product p sold to customers in period t

$P\ _p(t)$: Production cost of finished product p in period t

$SS_p\ (t)$: Sales of finished product p sold to the customers in period t

➢ *Other parameters*

LS_p: Production lot size of the finished product p

$_p$: Percentage of the cost of finished product *p* allowing to define the product carrying cost per period (cost of finished product *p* includes producing cost with regular, overtime and subcontracting capacity, plus set-up cost, and purchasing, transporting component/material *m*)

$_m$: Percentage of the cost of component/material *m* allowing to define the material carrying cost per period (cost of material *m* includes purchasing and transporting component/ material *m*)

MR_m : Material cost of component/material *m* bought from supplier during the horizon

MT_m : Material transportation cost of component/material *m* from supplier during the horizon

$M\ _m$: Material inventory carrying cost of component/material *m* during the horizon

MP_m: Material penalty cost of component/material *m* paid by supplier during the horizon

PH_m: Purchasing cost of component/material *m* from supplier during the horizon

PR_p: Regular capacity cost to produce finished product *p* during the horizon

PO_p: Overtime capacity cost to produce finished product *p* during the horizon

PS_p: Subcontracting cost to purchase finished product *p* during the horizon

$S\ _p$: Set-up cost to produce finished product *p* during the horizon

$P\ _p$: Product inventory carrying cost of finished product *p* during the horizon

$P\ \ _p$: Product penalty cost of finished product *p* paid by the manufacturer during the horizon

$P\ \ _p$: Production cost of the manufacturer for finished product *p* during the horizon

SS_p: Sales of finished product *p* sold to the customers during the horizon

TT_p: Total cost of the manufacturer for product during the horizon *p*, including purchasing and producing costs

N : Benefit of the manufacturer during the horizon

- *Constraints among parameters*

1) In each period *t*, the number of parts produced with overtime capacity should be less than the maximum possible:

$$O_p^t \leq MO_p \qquad \forall\, t\,, \forall\, p \text{ ……………………………………………………..(1)}$$

2) In period *t*, the quantity of available finished product *p* is equal to $Q_p^t + O_p^t + A_p^t$ (produced quantities plus all the finished products purchased from the subcontractor), plus the stored quantity ${}_p^{t-}$ available at the end of the previous period *t-1*. The delivered quantity ${}_{c\ p}^{t\ i}$ plus the stored quantities ${}_p^t$ at the end of period *t* should be the equal to the previous quantity.

$$Q_p^t + O_p^t + A_p^t + {}_p^t = \sum_c \sum_i {}_{c\ p}^{t\ i} + {}_p^t \qquad \forall\, c\,, \forall\, t\,, \forall\, i\,, \forall\, p \text{…………(2)}$$

3) In period *t*, the stored quantity ${}_m^{t-}$ of component/material at the end of the previous period *t-1* should at least satisfy the internal material requirements to manufacture the finished product during period t, even taking into account the

overtime capacity, so considering quantity $Q_p^t + O_p^t$ (we suppose the coefficient of BOM is 1).

$$ {}_m^t \geq Q_p^t + O_p^t \qquad \forall\, t, \forall\, p, \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

1.3. Total cost of the manufacturer

1.3.1. Purchasing cost

The purchasing cost is the sum of the material cost and transportation cost.

1) Material cost $MR_m(t)$: in period t, the quantity $S_m^{t\ i}$ of component/material m in each period t, is purchased from supplier, with a purchasing price PP_m.

$$MR_m(t) = \sum_i \left(S_m^{t\ i} \cdot PP_m\right) \qquad \forall\, t, \forall\, i, \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

During the periods *{t}* of the horizon, the total cost is the sum of the costs for each period:

$$MR_m = \sum_t^T MR_m(t) \qquad \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

2) Material transportation cost $MT_m(t)$: the idea is here to express that delivering often small quantities is more expensive than delivering large quantities less often. In that purpose, we define here the transportation of each quantity as the sum of a cost independent from the quantity plus a cost per part.

$$MT_m(t) \quad T\ \ _m \quad \sum_i \left(T\ \ _m\ S_m^{t\ i}\right) \qquad \forall\, i, \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

For all the periods of the horizon:

$$MT_m = \sum_t^T MT_m(t) \qquad \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

3) Material inventory carrying cost $M\ \ _m(t)$: in period t, the quantity ${}_m^t$ of component/material m is stored in the material inventory. It is theoretically necessary to take into account the real purchasing cost of the components during the period (material cost per unit remains unchanged from one supplier), plus the total transportation cost. Since the transportation cost may changes due to the quantity, we shall consider an average transportation cost on the horizon by saying that one unit in one period costs $\frac{MT}{\sum_i S_m^{t\ i}}$.

$$M\ \ _m(t) = \ \ _m \cdot \ {}_m^t \cdot \left(PP_m + \frac{MT}{\sum_t \sum_i S_m^{t\ i}}\right) \qquad \forall\, t, \forall\, i, \forall\, m \ldots\ldots\ldots\ldots(8)$$

During the periods of *{t}* with a horizon of *T*, it is the sum of each period:

$$M_{m} \quad \sum_{t}^{T} M_{m}(t) \qquad \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

4) Material penalty cost $MP_m(t)$ (due to a delayed delivery of component/material m): in period t, the quantity $S_m^{t\ i}$ purchased is delivered in period t, but should have been delivered in period i, ($i < t$). The penalty cost is $S_{\ m}$ for one unit delayed. The material penalty cost for one product and one period is calculated as the total of the backlogs. Here, the orders should not be delivered in advance.

$$MP_m(t) = \begin{cases} 0 & , t \le i \\ \sum_{i} \left(S_{\ m} \cdot (t-i) \cdot S_m^{t\ i}\right) & , t > i \end{cases} \qquad \forall\, t, \forall\, i, \forall\, m \ldots\ldots\ldots\ldots\ldots (10)$$

During the horizon, the total penalty is the sum of the penalty cost for each period:

$$MP_m \quad \sum_{t}^{T} MP_{m}(t) \qquad \forall\, m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Therefore, the purchasing cost $PH_m(T)$ on the whole horizon is:

$$PH_{m} \quad \sum_{t}^{T} PH_{m}(t) = \sum_{t}^{T} \left(MR_m(t) + MT_m(t) + M_{\ m}(t) - MP_m(t)\right) \qquad \forall\, m \ldots (12)$$

1.3.2. Production cost

The production cost may be calculated on the base of a resource cost (which can be either a regular capacity cost, an overtime capacity cost, or a subcontracting cost for purchasing finished products), a set-up cost, an inventory carrying cost, and a penalty cost for delayed delivery of the finished product.

1) Regular capacity cost $PR_p(t)$: in period t, the quantity Q_p^t of finished product p is produced in each period with the regular capacity, with cost $R_{\ p}$ for one unit. This regular cost is different for the various finished products, depending on the used work center.

$$PR_p(t) = Q_p^t \cdot R_{\ p} \qquad \forall\, t, \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

On all the periods:

$$PR_p \quad \sum_{t}^{T} PR_{p}(t) \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

2) Overtime capacity cost $PO_p(t)$: in period t, it is based on the quantity O_p^t of finished product p which is produced by over time capacity, and the cost $_{p}$ for over time capacity producing one unit of finished product p

$$PO_p(t) = O_p^t \cdot \quad {}_p \qquad \forall\, t, \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

On all the periods:

$$PO_p \quad \sum_{t}^{T} PO_p(t) \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

3) Subcontracting cost $PS_p(t)$: in period t, it is based on the quantity A_p^t of finished product p which is purchased from the subcontractor (only one subcontractor is considered here), and the purchasing cost $P \ {}_p$ for one unit of finished product p.

$$PS_p(t) = A_p^t \cdot \ P \ {}_p \qquad \forall\, t, \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

On the horizon:

$$PS_p \quad \sum_{t}^{T} PS_p(t) \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

4) Set-up cost $S \ {}_p(t)$: we want to show here the possible interest to group parts in larger lots than the defined manufacturing lot size LS_p. Therefore, a set-up will be considered for each lot when no grouping is performed. Negotiation in this case will result in grouping several lots for decreasing the number and cost of set-ups. In period t, with a defined lot size LS_p and without negotiation, the number of the set-ups is calculated as the ceiling function of the total quantity of each period, including the quantity Q_p^t of finished product p produced with the regular capacity and the quantity O_p^t of finished product p, produced with overtime capacity, over the manufacturing lot size LS_p. Accordingly, the set-up cost is calculated as the number of set-up times, multiplied by the set-up cost ST_p.

$$S \ {}_p(t) = \left\lceil \frac{Q_p^t + O_p^t}{LS_p} \right\rceil \cdot ST_p \qquad \forall\, t, \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

On the horizon:

$$S \ {}_p \quad \sum_{t}^{T} S \ {}_p(t) \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

5) Product inventory carrying cost $P \ {}_p(t)$: in period t, the quantity ${}_p^t$ of finished product p is stored in the finished product inventory. For these stored finished products p, the carrying cost is a percentage ${}_p$ of the cost of the product. The product cost is calculated as the capacity cost used to produce the product (including set-up cost) and/or the subcontracting cost used to purchase it from the subcontractor, plus material and transportation costs. Since the same finished product can be produced with different costs (e.g. using regular capacity or subcontracting capacity), we use the average of these costs on the period.

$$P\ \ _p(t) \qquad _p \cdot \ ^t_p \cdot \left(\frac{PR_p(t) + PO_p(t) + S\ \ _p(t) + PS_p(t)}{Q_p^t + O_p^t + A_p^t} + PP_m + \frac{MT}{\sum_t \sum_i S_m^{t\ i}} \right)$$

$$\forall\, t\,, \forall\, i\,, \forall\, p \text{ ....(21)}$$

On the horizon, the total final product carrying cost is the sum of the costs for each period:

$$P\ \ _p \quad \sum_t^T P\ \ _p(t) \qquad \forall\, p \text{..(22)}$$

6) Product penalty cost (due to delayed delivery of finished product) $P\ \ _p(t)$: in period t, among the quantity of $\ ^{t\ i}_{c\ p}$ of finished product p sold to customer c, if the real delivery period t is later than the required delivery period i ($t > i$), the order is in the status of backlog, and a cost $S\ \ _p$ is applied for each product unit for penalty. It should take into account all the customers *{c}*.

$$P\ \ _p(t) = \begin{cases} 0\,, t \le i \\ \sum_c \sum_i \left(S\ \ _p \cdot (t - i) \cdot \ ^{t\ i}_{c\ p} \right), t > i \end{cases} \qquad \forall\, t\,, \forall\, i\,, \forall\, c\,, \forall\, p \text{.........(23)}$$

On the horizon, the total product penalty cost is the sum of the penalty costs for each period:

$$P\ \ _p \quad \sum_t^T P\ \ _p(t) \qquad \forall\, p \text{...(24)}$$

Therefore, the total production cost on the horizon is equal to:

$$P\ \ _p \quad \sum_t^T P\ \ _p(t) = \sum_t^T \left(PR_p(t) + PO_p(t) + PS_p(t) + S\ \ _p(t) + P\ \ _p(t) + P\ \ _p(t) \right)$$

$$\forall\, p \text{...........................(25)}$$

The total cost during the horizon is thereby calculated as:

$$TT_p = PH_m + P\ \ _p = \sum_t^T PH_m(t) + \sum_t^T P\ \ _p(t) \qquad \forall\, m, \forall\, p \text{......................(26)}$$

1.4. Sales

The sale revenue $SS_p\,(t)$ in period t has also to be calculated: the quantity $\ ^{t\ i}_{c\ p}$ of finished product p is sold to the customer c, with the sale price $SP_{c\ p}$ (sales price may be different depending on the customer c). Therefore, the sales are:

$$SS_p\,(t) \;=\sum_{c}\left(SP_{c\;p} \cdot \sum_{i}\;\;{}^{t\;i}_{c\;p} \right) \qquad \forall\, t\,, \forall\, i\,, \forall\, c\,, \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (27)$$

On the horizon, the sales revenue is the sum of the revenues for each period:

$$SS_p \quad \sum_{t}^{T} SS_{\,p}(t) \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (28)$$

On the horizon, the benefit is the sum of the benefits on each period:

$$N \;\; = SS_p \; - \; TT_{\,p} \qquad \forall\, p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (29)$$

The suggested cost model is only a simplified example for calculating different kinds of cost in the processes of procurement, production and delivery. Even if the real cost calculation are in practice more complex and precise, we do believe that this cost model can illustrate quite realistic situations of the proposed negotiation process. In next section, we simulate examples of the negotiation processes and calculate the related costs in order to show the possible interest of negotiation.

2. Simulations of negotiation processes

In this section, we are going to illustrate the negotiation processes based on some simple numerical examples concerning the previous mentioned items: periods of forecast, load variation, price and cycle time, and priority and lot size. For each item, we firstly introduce what should occur in a "classical" context (denoted here as "normal cases"), build the scenario(s) and calculate the costs according to the suggested cost model. Secondly, we specify some typical negotiation scenario(s) on the same problem, and we compare the costs after negotiation and the "normal" ones. The primary purpose of these simulations is to show the practical possibilities of our suggested negotiation processes based on risks sharing and cost assessment.

2.1. Basis of simulation

In the simulations, we focus on a simple linear relationship, including one customer, one manufacturer, and one supplier (the supplier and the manufacturer may be involved in other supply chains, therefore their capacity may be shared with other supply chains in the same period, which is not explicitly modeled it here). The supplier has a purchasing lead time of 1.5 months (6 weeks) to supply the required component *A-1-1*, with a lot size of 10 units. The supplier needs 2 weeks to produce its finished product *A-1* using component *A-1-1* then put it into his product inventory. The manufacturer purchases component *A-1* from the supplier, stores it in his material inventory with a lot size of 10 units. Using component *A-1*, the manufacturer produces the finished product *A*, with an internal cycle time of 1 month and a lot size of 10 units. The finished product *A* is then sold to the final customer as required. Therefore, the structure of the simulated supply chain and related technical data are showed in Figure 4.2.

The firm and flexible periods of the forecasts will be defined when needed according to the considered scenario. The forecasts are supposed to be updated every month.

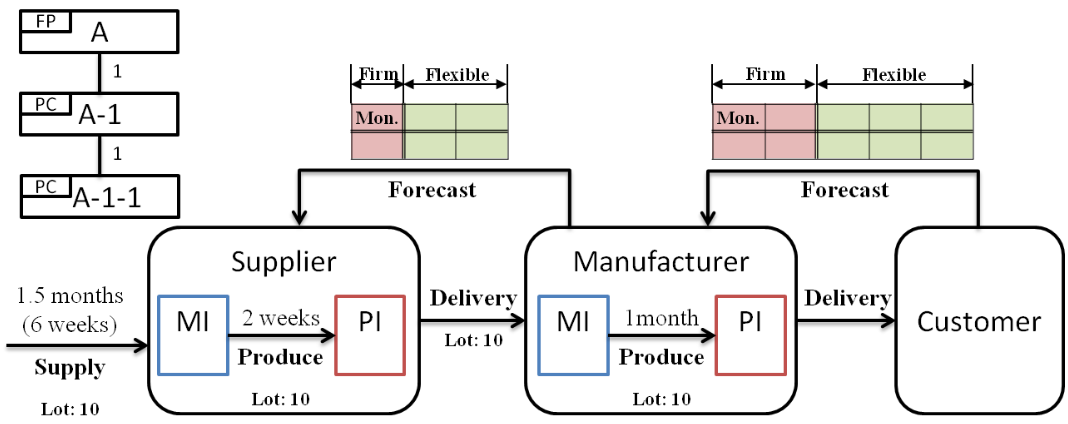

Figure 4.2. The structure of simulated supply chain and related technical data

The elementary prices and costs required in the processes of procurement, production and delivery are described in the cost model. Of course, the interest of the negotiation process depends on the relative values of these costs: for instance, a high penalty cost and a low carrying cost will lead to prefer storage than shortage. Let us underline that these simulations do not aim at demonstrating that negotiation is always of interest, but only that it can be useful in some cases. The elementary costs are defined as follows:

For the manufacturer:

$SP_{c\ A}$: 100 € (sale price of the manufacturer for one unit of *A*)
PP_{A-} : 75 € (purchasing price of one unit of *A-1* for the manufacturer)
$R_{\ A}$: 20 € (unitary cost for manufacturer to use regular capacity to manufacture *A*)
$_{A}$: 30 € (unitary cost for manufacturer to use overtime capacity to manufacture *A*)
$P_{\ A}$: 40 € (price for purchasing one unit of *A* from the subcontractor)
$S_{\ A}$: 10 € (penalty cost for manufacturer to delay deliver one unit of *A* in one period)
ST_A: 20 € (set-up cost for manufacturer to produce one lot-size of the *A*)
$T_{\ A-}$: 70 € (cost for one quantity-independent transportation of *A-1* from the supplier)
$T_{\ A-}$: 5 € (price for manufacturer to transport one extra unit of *A-1* from the supplier)
$_{A}$: 30% /year (coefficient of inventory carrying cost for finished product *A*)
$_{A-}$: 30% /year (coefficient of inventory carrying cost for component *A-1*)
MO^t_A: 30 units (maximum overtime capacity)

For the supplier:

$SP_{c\ A-}$: 75 € (sale price of one unit of *A-1* from the supplier to the manufacturer)
$PP_{s\ A-\ -}$: 50 € (purchasing price of one unit of *A-1-1* for the supplier)
$R_{\ A-}$: 10 € (unitary cost for supplier to use regular capacity to manufacture *A-1*)
$_{A-}$: 15 € (unitary cost for supplier to use overtime capacity to manufacture *A-1*)
$P_{a\ A-}$: 20 € (price of one unit of *A-1* from the subcontractor)
$S_{\ A-}$: 1 € (penalty cost of the supplier for the shortage of one unit of *A-1* in one period)
ST_{A-} : 5 € (set-up cost for supplier to produce one lot of *A-1*)

$T_{A\text{-}\ \text{-}}$:	50 € (cost for one quantity-independent transportation of *A-1-1* from his supplier)
$T_{s\ A\text{-}\ \text{-}}$:	2 € (cost for the supplier to transport one extra unit of *A-1-1*)
$_{A\text{-}}$:	25% /year (coefficient of inventory carrying cost for finished product *A-1*)
$_{A\text{-}\ \text{-}}$:	25% /year (coefficient of inventory carrying cost for component *A-1-1*)
$MO^{t}_{A\text{-}}$:	40 units (maximum overtime capacity)

2.2. Periods of forecast

The main interest of the negotiation on the periods of forecast is to protect the supplier. Therefore, we shall define here a scenario that we have seen in the interviews, i.e. the case when the supplier has to order parts on the base of the flexible period of the forecasts he receives from the manufacturer (his customer).

In this simulation, we suppose that the manufacturer receives a customer's forecast for his finished product *A* with 2 months of firm period and 3 months of flexible period. Based on the sales plan and production plan, the manufacturer sends his supply plan/forecast for component A-1 to his supplier, with 1 month of firm period and 2 month of flexible period. Since the supplier has a cycle time of 2 months (1.5 months of supply lead time for component A-1-1 and 2 weeks of internal cycle time for producing his finished product A-1), which is longer than the firm period of forecast he receives, the supplier has to order the component A-1-1 based on the flexible period of his forecasts, in order to fulfill the requirements from the manufacturer on time. Doing so, he takes the risk of variations in the flexible period. Another option is that the supplier does not perform his procurement process till the orders from the manufacturer are firmed, which certainly leads to delay delivery, and related penalty costs. For being able to compare the consequences of the possible decisions of the supplier, we shall consider possible evolutions of the forecasts successively sent to him by the manufacturer.

2.2.1. Normal case

In the "normal" cases (no negotiation), we test the following situations:

- Case 1: the supplier orders the components on the base of the flexible period. As a consequence, the situations on the supplier's side heavily depend on the variations of the requirements from the manufacturer. In order to test the differences between situations, we consider three scenarios as following and calculate the costs and benefits on the supplier's side based on the numerical simulations (the calculations are performed until week 12 and the scenarios have the same horizon).

- Scenario 1.1: everything is confirmed in the following forecasts (see appendix I and II)

From the MRP plan of the supplier, we calculate the material cost based on the line of "net requirements" which also represents the purchasing from the supplier's supplier. As Figure 4.3 shows, there are 6 purchasing orders, with a quantity of 60 units for each. Thereby, the material cost and material transportation costs can be calculated. For the carrying cost of material inventory, the calculation is based on the line of "projected stock". The detailed calculations for the material purchasing cost are:

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50		50			50				50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	10	10	10	10	10	10	10	20	20	20	20
Net requirement			60		60		60			60			60					60			50				60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60			50				60									

Figure 4.3. MRP of the supplier in scenario 1.1 of normal case in Period of forecast simulation

Material purchasing cost $MR_{A- -}$: $6 \times 60 \times 50 = 18000$ €

Material transportation cost $MT_{A- -}$: $50 + 360 \times 2 = 770$ €

Material inventory carrying cost $M_{A- -}$: $\frac{25}{52} \times 450 \times \left(50 + \frac{770}{360}\right) = 113$ €

Material Penalty cost $MP_{A- -}$: 0 €

Purchasing cost: $PH_{A- -} = 18000 + 770 + 113 = 18883$ €

From the MPS plan of the supplier, we calculate the production cost. The line "MO receipt" in Figure 4.4 represents the manufacturer orders and their quantity, the number of set-up times, which are used to calculate producing cost (including regular capacity, overtime capacity, subcontracting capacity and set-up cost). The line of "Projected stocks" represents the inventory level and the product inventory carrying cost is determined based on this. By comparing the stock level and the firmed orders, the delay orders are clearly presented and the penalty cost paid to the manufacturer is identified.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40			40			40		40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	30	30	30	40	40	40	0	50	10
MO receipt					50		50		50			50			50			50		50			50				50	
MO release			50		50		50			50			50			50		50			50				50			

Figure 4.4. MPS of the supplier in scenario 1.1 of normal case in Period of forecast simulation

The detailed calculations for production cost are:

Regular capacity cost PR_{A-} : $7\ 50 \times 10 = 3500$ €

Overtime capacity cost PO_{A-} : 0 €

Subcontracting capacity cost PS_{A-} : 0 €

Set-ups cost S_{A-} : $7 \times 5 = 35$ €

Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 290 \times \left(\frac{3200}{320} + 50 + \frac{770}{360}\right) = 87$ €

Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 3500 + 35 + 87 = 3622$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A\text{-}} = 18883 + 3622 = 22505$ €

The sales of finished product could be calculated based on the firmed order sent by the manufacturer and the real delivery situation from its MRP plan, see Figure 4.5 (we will mark them under the line "PO (purchasing order) receipt" with red color). In this case, no delays exist; the delivery is performed as required and the Sales are calculated as following:

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	20	30	0	0	10	10	20	20	20	20	20
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40			40			40		40				

Figure 4.5. MRP of the manufacturer in scenario 1.1 of normal case in Period of forecast simulation

Sales $SS_{A\text{-}}$: $320 \times 75 \quad 24000$ €

Benefit during the horizon:

$$N = SS_{A\text{-}} - TT_{A\text{-}} = 24000 - 22505 = 1495 \text{ €}$$

In this scenario, everything is confirmed in the following forecasts and the supplier earns some money.

- Scenario 1.2: the following forecasts are less than expected (see appendix I and III)

The changes of the requirement between the previous and the current forecasts are marked in red in Figure 4.6. Until week 12, the forecast is less than expected in the previous forecast (the previous volume is marked in the above line of the current volume).The calculations of the costs are similar than with the previous scenarios.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**15**	**15**	**15**	**15**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	0	15	0	15	0	15	0	15	25	5	15	25	10	25	5	15
MO receipt									30		30		30	30		30		30		30		30		30	30		30	30		30		30
MO release					30		30		30	30		30		30		30		30		30	30		30	30		30		30				

Figure 4.6. MPS of the manufacturer in scenario 1.2 of normal case in Period of forecast simulation

Material purchasing cost $MR_{A\text{-}\ \_}$: $6 \times 60 \times 50 = 18000$ €

Material transportation cost $MT_{A\text{-}\ \_}$: $50 + 360 \times 2 = 770$ €

Material inventory carrying cost $M_{A\text{-}\ \_}$: $\frac{25}{52} \times 650 \times \left(50 + \frac{770}{360}\right) = 163$ €

Material Penalty cost $MP_{A\text{-}\ \_}$: 0 €

Purchasing cost: $PH_{A\text{-}\ \_} = 18000 + 770 + 163 = 18933$ €

Regular capacity cost $PR_{A\text{-}}$: $6 \times 50 \times 10 = 3000$ €

Overtime capacity cost $PO_{A\text{-}}$: 0 €

Subcontracting capacity cost $PS_{A\text{-}}$: 0 €

Set-ups cost S_{A-} : $6 \times 5 = 30$ €

Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 290 \times \left(\frac{3000}{300} + 50 + \frac{770}{360}\right) = 87$ €

Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 3000 + 30 + 87 = 3117$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 18933 + 3117 = 22050$ €

Sales SS_{A-} : 280 75 2 1000 €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} \quad 21000 - 22050 \quad - 1050 \text{ €}$$

In this scenario, the supplier loses money. A reason is that he needs to maintain a temporary high level of material inventory because of his purchases based on the flexible period of the received forecasts. Accordingly, the material carrying cost covers a larger part of the material cost than in the previous scenario.

- Scenario 1.3: the following forecasts are more than expected (see appendix I and IV)

In scenario 1.3, 7 purchasing orders for material were performed due to the increased requirements. However, there are backlogs in the material inventory, since the previous purchasing is based on the flexible period with less quantity than confirmed. New purchases are in the progress but do not have time to arrive, see Figure 4.7.

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50		50		50		50					50	50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	0	0	-50	10	20	20	20	20	20	30	40	40	40	40
Net requirement			60		60		60			60			60					60	60					60	60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60	60					60	60									

Figure 4.7. MRP of the supplier in scenario 1.2 of normal case in Period of forecast simulation

As a consequence, there are two orders delayed from the supplier to the manufacturer (see Figure 4.8): order of 40 parts required in week 6 but delivered on week 7; order of 40 parts required in the week 11 but delivered on time with 20 units. The rest is delayed till week 13.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	25	25	25	25	15	15	15	15	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	15	0	5	20	5	20	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30	20	10	30	30		30		30	30		30		30	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
														20	add 10																	

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	-10	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	40			40		40	40				40		40	40					
														0	add 40				20	add 10add 10												

Figure 4.8. MPS and MRP of the manufacturer in scenario 1.2 of normal case in Period of forecast simulation

However, such delays do not affect the manufacturer, due to his local inventory. The detailed calculations are:

Material purchasing cost $MR_{A-\ -}$: $7 \times 60 \times 50 \;=\; 21000$ €

Material transportation cost $MT_{A-\ -}$: $50 + 420 \times 2 \;=\; 890$ €

Material inventory carrying cost $M_{A-\ -}$: $\frac{25}{52} \times 420 \times \left(50 + \frac{890}{420}\right) = 105$ €

Material Penalty cost $MP_{A-\ -}$: 0 €

Purchasing cost: $PH_{A-\ -} = 21000 + 890 + 105 = 21995$ €

Regular capacity cost PR_{A-} : 7 50 10 3500 €

Overtime capacity cost PO_{A-} : 0 €

Subcontracting capacity cost PS_{A-} : 0 €

Set-ups cost S_{A-} : 7 5 35 €

Product inventory carrying cost P_{A-} : $\frac{25}{52}$ 250 $\left(\frac{3500}{350}\ 50\ \ \frac{890}{420}\right)$ 75 €

Product penalty cost P_{A-} : 40 (7-6) 1 40 (13-11) 1 120 €

Production cost: $P_{A-} = 3500 + 35 + 75 + 120 = 3730$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 21995 + 3730 = 25725$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} = 27000 - 25725 = 1275 \text{ €}$$

- Case 2: the supplier only orders according to the firm period

In the second normal scenario, we suppose that the supplier does not send purchases to his supplier until the orders are firmed, taking the risk of possible delayed delivery and corresponding penalty costs. When the forecasts from the manufacturer are confirmed each month, the supplier can only perform purchasing orders at the beginning of the month (the earliest moment), while the materials will only arrive 6 weeks later. We divide the case into three scenarios, the same ones than in previous case.

- Scenario 2.1: everything is confirmed (see appendix V).

  Material purchasing cost $MR_{A-\ -}$: $5 \times 60 \times 50 = 15000$ €
  Material transportation cost $MT_{A-\ -}$: $50 + 300 \times 2 = 650$ €
  Material inventory carrying cost $M_{A-\ -}$: $\frac{25}{52} \times 420 \times \left(50 + \frac{650}{300}\right) = 105$ €
  Material Penalty cost $MP_{A-\ -}$: 0 €

  Purchasing cost: $PH_{A-\ -} = 15000 + 650 + 105 = 15755$ €

  Regular capacity cost PR_{A-} : $6 \times 50 \times 10 = 3000$ €
  Overtime capacity cost PO_{A-} : 0 €
  Subcontracting capacity cost PS_{A-} : 0 €
  Set-ups cost S_{A-} : $6 \times 5 = 30$ €
  Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 260 \times \left(\frac{3000}{300} + 50 + \frac{650}{300}\right) = 78$ €
  Product penalty cost P_{A-} : $40 \times (17 - 12) \times 1 = 200$ €

  Production cost: $P_{A-} = 3000 + 30 + 78 + 200 = 3308$ €

Eventually, the total cost until the week 12 is:

  Total cost: $TT_{A-} = 15755 + 3308 = 19063$ €

  Sales SS_{A-} : $320 \times 75 = 24000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} = 24000 - 19063 = 4937 \text{ €}$$

Due to less purchasing, the supplier earns benefits instead of losing money, but there are delays even when everything is confirmed as forecasted, see Figure 4.9.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	10	15	15	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	15	0	-15	-35	10	25	5	15
MO receipt									30		30		30	30		30	30		30	30		30		30			0	0	60	30		30
MO release					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
																							0	0	add 60							

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	0	0	0	-30	-60	0	10	10	20	20	20	20	20
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40			40			40		40				
																				20			0		add 60							

Figure 4.9. MPS and MRP of the manufacturer in scenario 2.1 of normal case in Period of forecast simulation

As a consequence, the delayed deliveries from the supplier have impacts on the manufacturer's side leading to two orders delayed towards to the end customer (see

Figure 4.9). Accordingly, the manufacturer needs to pay penalty costs for his customer. The penalty costs on the manufacturer's side are:

Material Penalty cost MP_{A-} : $40 \times (17 - 12) \times 1 = 200$ €
Product penalty cost P_{A}: $15 \times (21 - 19) \times 10 + 20 \times (21 - 20) \times 10 = 500$ €

Therefore, the manufacturer has to pay his customer 500 € for penalty cost linked to delayed deliveries of product *A,* while he receives 200 € from his supplier for the delays o then purchased material *A-1*. However the received penalty cost does not compensate the manufacturer's lost and it is obvious that the manufacturer is losing money on the penalty costs (the manufacturer may earn benefits but pay more for penalty cost).

- Scenario 2.2: the following forecasts are less than expected (see appendix VI)

Material purchasing cost $MR_{A-\,-}$: $5 \times 60 \times 50 = 15000$ €
Material transportation cost $MT_{A-\,-}$: $50 + 300 \times 2 = 650$ €
Material inventory carrying cost $M_{A-\,-}$: $\frac{25}{52} \times 570 \times \left(50 + \frac{650}{300}\right)$ 143 €
Material Penalty cost $MP_{A-\,-}$: 0 €

Purchasing cost: $PH_{A-\,-} = 15000 + 650 + 143 = 15793$ €

Regular capacity cost PR_{A-} : $6 \times 50 \times 10 = 3000$ €
Overtime capacity cost PO_{A-} : 0 €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : $6 \times 5 = 30$ €
Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 290 \times \left(\frac{3000}{300} + 50 + \frac{650}{300}\right) = 87$ €
Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 3000 + 30 + 87 = 3117$ €

The total cost until the week 12 is:

Total cost: $TT_{A-} = 15793 + 3117 = 18910$

Sales SS_{A-} : $280 \times 75 = 21000$ €

Benefit during the horizon:

$N = SS_{A-} - TT_{A-} = 21000 - 18910 = 2090$ €

With less purchasing and decreased requirements, the supplier could still earn some benefits and has less backorders. In the accounting horizon, no delays exit but delays occur in the following periods.

- Scenario 2.3: the following forecasts are more than expected (see appendix VII)

Material purchasing cost $MR_{A-\,-}$: $5 \times 60 \times 50 = 15000$ €
Material transportation cost $MT_{A-\,-}$: $50 + 300 \times 2 = 650$ €

Material inventory carrying cost $M_{A- -}$: $\frac{25}{52} \times 370 \times \left(50 + \frac{650}{300}\right) = 93$ €
Material Penalty cost $MP_{A- -}$: 0 €

Purchasing cost: $PH_{A- -} = 15000 + 650 + 93 = 15743$ €

Regular capacity cost PR_{A-} : $6 \times 50 \times 10 = 3000$ €
Overtime capacity cost PO_{A-} : 0 €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : $6 \times 5 = 30$ €
Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 250 \times \left(\frac{3000}{300} + 50 + \frac{650}{300}\right) = 75$ €
Product penalty cost P_{A-} :

$$40 \times (7 - 6) \times 1 + 40 \times (17 - 11) \times 1 + 40 \times (17 - 12) \times 1 = 480 \text{ €}$$

Production cost: $P_{A-} = 3000 + 30 + 75 + 480 = 3585$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 15743 + 3585 = 19328$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} = 27000 - 19328 = 7672 \text{ €}$$

In scenario 2.3, the supplier performs less purchasing orders, (and only when the orders from the manufacturer are confirmed), but simultaneously faces increased requirements. As a consequence, supplier has to deal with more backorders and delayed deliveries. These delays induce high penalty costs and may also affect the manufacturer, leading to manufacturer's delayed deliveries towards the customer. In our simulation, this effect occurs. The penalty costs on the manufacturer's side are:

Material Penalty cost MP_{A-} :

$$40 \times (7 - 6) \times 1 + 40 \times (17 - 11) \times 1 + 40 \times (17 - 12) \times 1 = 480 \text{ €}$$

Product penalty cost P_{A}:

$$20 \times (21 - 17) \times 10 + 20 \times (21 - 18) \times 10 + 20 \times (22 - 19) \times 10 + 20 \times (22 - 10) \times 10 = 2400 \text{ €}$$

Obviously, the manufacturer has to pay 2400 € for penalty costs to his customer, but only receives 480 € from his supplier. The manufacturer is losing money on the penalty costs (totally, the manufacturer may earn benefits, but the penalty cost he pays is a larger percentage of his total costs).

Based on the normal cases, the simulated results show us that when the supplier has to deal with a short length of the firmed period (less than his internal cycle time), risks inevitably exist. These risks are not only found at the supplier's side, but also may be identified at the manufacturer's side.

2.2.2. Negotiation case

We shall now consider the same cases within negotiation processes.

- Negotiation Case 1: We suppose first that negotiation has allowed the supplier to obtain a firm period of 8 weeks from his customer, the manufacturer. We take the example of increased requirement. (see appendix VIII)

  Material purchasing cost $MR_{A-\ -}$: $7 \times 60 \times 50 = 21000$ €
  Material transportation cost $MT_{A-\ -}$: $50 + 420 \times 2 = 890$ €
  Material inventory carrying cost $M\ _{A-\ -}$: $\frac{25}{52} \times 400 \times \left(50 + \frac{890}{420}\right) = 100$ €
  Material Penalty cost $MP_{A-\ -}$: 0 €

  Purchasing cost: $PH_{A-\ -} = 21000 + 890 + 100 = 21990$ €

  Regular capacity cost PR_{A-} : $7 \times 50 \times 10 = 3500$ €
  Overtime capacity cost PO_{A-} : 0 €
  Subcontracting capacity cost PS_{A-} : 0 €
  Set-ups cost $S\ _{A-}$: $7 \times 5 = 35$ €
  Product inventory carrying cost $P\ _{A-}$: $\frac{25}{52} \times 250 \times \left(\frac{3500}{350} + 50 + \frac{890}{420}\right) = 75$ €
  Product penalty cost $P\ _{A-}$: $40 \times (13 - 11) \times 1 = 80$ €

  Production cost: $P\ _{A-} = 3500 + 35 + 75 + 80 = 3690$ €

  Eventually, the total cost until the week 12 is:

  Total cost: $TT_{A-} = 21990 + 3690 = 25680$ €

  Sales SS_{A-} : $360 \times 75 = 27000$ €

  Benefit during the horizon:

  $$N\ = SS_{A-} - TT_{A-} = 27000 - 25680 = 1320 \text{ €}$$

In negotiation case 1, it is the same requirement with normal case, the scenario 1.3. Comparing to the scenario 1.3, the supplier deals with longer firmed period, suffers from only one backorder and gains a little bit more benefits. On the manufacturer's side, one order is delayed due to the changes in his flexible period, but purchasing is already performed towards the supplier in the firmed period. As a consequence, the manufacturer could not change the purchasing orders as he wish. On this basis, the manufacturer may request for increasing the firmed period.

- Negotiation Case 2: The manufacturer has only obtained partial satisfaction. The firm period sent by the manufacturer is 6 weeks. We continue to consider the example of increased requirements (see appendix IX).

  Material purchasing cost $MR_{A-\ -}$: $7 \times 60 \times 50 = 21000$ €
  Material transportation cost $MT_{A-\ -}$: $50 + 420 \times 2 = 890$ €

Material inventory carrying cost $M_{A-\ -}$: $\frac{25}{52} \times 330 \times \left(50 + \frac{890}{420}\right) = 75$ €
Material Penalty cost $MP_{A-\ -}$: 0 €

Purchasing cost: $PH_{A-\ -} = 21000 + 890 + 75 = 21965$ €

Regular capacity cost PR_{A-} : $7 \times 50 \times 10 = 3500$ €
Overtime capacity cost PO_{A-} : 0 €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : $7 \times 5 = 35$ €
Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 270 \times \left(\frac{3500}{350} + 50 + \frac{890}{420}\right) \quad 80$ €
Product penalty cost P_{A-} : $40 \times (12 - 11) \times 1 = 40$ €

Production cost: $P_{A-} = 3500 + 35 + 80 + 40 = 3655$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 21965 + 3655 = 25620$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$N = SS_{A-} - TT_{A-} = 27000 - 25620 = 1380$ €

In negotiation case 2, the manufacturer has no backorders due to the delay delivery from the supplier, since the current stock would compensate some delays from the supplier.

Through the first negotiation (case 1) we show in our simulation that the manufacturer may consider he is taking too much risks (anyway more than his supplier) and may insist to decrease the horizon of the firmed periods. Thereby in negotiation case 2, a new horizon of the firmed periods is agreed and risks are shared between the supplier and the manufacturer. From our numerical results, the supplier earns more benefits in case 2 than in case 1, and the manufacturer is no longer facing backorders in case 2, showing that negotiation and sharing risks would in that case allow a win-win situation.

Despite, from our numerical results, the changes of inventory carrying cost and penalty costs due to the changes of firmed period horizon are low, the advantages of negotiation are still identical based on the number of backorders and the inventory level in the production plans.

2.3. Load variation

In the simulation of the negotiation process motivated by a load variation, we shall focus on an increased load, the inverse case being simpler to handle. We consider that an overload is presented in the flexible period. It is consistent with the contract, but the supplier is supposed to be already in overtime, due to orders coming from other customers. The supplier cannot fulfill all the orders with his available overtime capacity and would have to increase his cost by using the subcontracting capacity.

2.3.1. Normal case

In the normal case, we create a situation in which the supplier has to deal with three consecutive orders from the manufacturer, one in the firmed period and the other two in the flexible period. One order in the flexible period is newly confirmed, which is not planned in the previous forecasts. As a consequence, there is not enough capacity to fulfill it due to the capacity constraints. Therefore, the supplier must search for subcontracting or invest in extra hours for overtime capacity in order to satisfy the manufacturer. Figure 4.10 shows the previous MPS of the supplier in the month of January and the current MPS in the month of February.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40		40						
Projected stock (20)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	30	30	40	40	40	40	40	40	40
MO receipt					50		50		50			50			50			50		50		50						
MO release			50		50		50			50			50			50		50		50								

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40	40			40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	20	20	-20	-10	40	40	40	0	0	10	20	20
MO receipt					50		50		50			50		40	10		50		0	50	50					50	50	
MO release			50		50		50			50		40	10		50		50		50					50	50			
																	0	add 50										

Figure 4.10. MPS of the supplier in normal case in Load variation simulation

In Figure 4.10, we can see that the previous order on week 7 (40 units) has been moved ahead to week 6 in the current firmed orders. As a consequence, the supplier has to finish producing at least 40 units in week 6 in order to deal with such changes. We want to test two cases:

- Case 1: the supplier pays for subcontracting (see appendix I and X).

Material purchasing cost $MR_{A-\ -}$: $7 \times 60 \times 50 = 21000$ €

Material transportation cost $MT_{A-\ -}$: $50 + 420 \times 2 = 890$ €

Material inventory carrying cost $M_{\ A-\ -}$: $\frac{25}{52} \times 380 \times \left(50 + \frac{890}{420}\right) = 95$ €

Material Penalty cost $MP_{A-\ -}$: 0 €

Purchasing cost: $PH_{A-\ -} = 21000 + 890 + 95 = 21985$ €

Regular capacity cost PR_{A-} : $(6 \times 50 + 10) \times 10 = 3100$ €

Overtime capacity cost PO_{A-} : 0 €

Subcontracting capacity cost PS_{A-} : $40 \times 40 = 1600$ €

Set-ups cost $S_{\ A-}$: $7 \times 5 \quad 35$ €

Product inventory carrying cost $P_{\ A-}$: $\frac{25}{52} \times 250 \times \left(\frac{3100+800}{310+40} + 50 + \frac{890}{420}\right) = 76$ €

Product penalty cost $P_{\ \ A-}$: 0 €

Production cost: $P_{\ \ A-} = 3200 + 1600 + 35 + 76 + 80 = 4991$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 21985 + 4991 = 26976$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} = 27000 - 26976 = 24 \text{ €}$$

The simulated data in this case are identical with the normal case 1, scenario 1.3 in the negotiation of periods of forecast. Through the comparison, the production cost is inevitably increased due to the subcontracting cost, but the supplier reduces the numbers of backorders.

- Case 2: the supplier uses only his regular capacity and pays the penalty costs.

We suppose that the supplier chooses to only use his regular capacity and postpones the orders required in week 6 to week 7, since in week 7 there is enough available capacity. The costs are the same than in the normal case 1, scenario 1.3 in the negotiation of periods of forecast (see appendix I and IV). These costs are:

Material purchasing cost $MR_{A- \ -}$: $7 \times 60 \times 50 = 21000$ €
Material transportation cost $MT_{A- \ -}$: $50 + 420 \times 2 = 890$ €
Material inventory carrying cost $M_{A- \ -}$: $\frac{25}{52} \times 420 \times \left(50 + \frac{890}{420}\right) = 105$ €
Material Penalty cost $MP_{A- \ -}$: 0 €

Purchasing cost: $PH_{A- \ -} = 21000 + 890 + 105 = 21995$ €

Regular capacity cost PR_{A-} : 7 50 10   3500 €
Overtime capacity cost PO_{A-} : 0 €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : 7 5   35   €
Product inventory carrying cost P_{A-} : $\frac{25}{52}$ 250 $\left(\frac{3500}{350} \ 50 \ \ \frac{890}{420}\right)$ 75 €
Product penalty cost P_{A-} : 40 (7-6) 1 40   (13-11) 1 120   €

Production cost: $P_{A-} = 3500 + 35 + 75 + 120 = 3730$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 21995 + 3730 = 25725$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} = 27000 - 25725 = 1275 \text{ €}$$

By comparing these two cases, it is obvious that if the supplier chooses to postpone orders when dealing with an increased load, he could earn more money but may pay penalty costs. However, the manufacturer may suffer from delayed deliveries which accordingly may lead to delayed deliveries to the end customer. As a consequence, the manufacturer may need to pay penalty costs to his customer.

2.3.2. Negotiation case

In the negotiation case, we consider that the supplier manages to get a part of his over costs paid by the manufacturer. He makes some benefit and the manufacturer does not have penalties. Both of the supplier and the manufacturer may earn benefits comparing with the two previous cases.

➢ Negotiation case 1: the manufacturer re-ranges the load and charges no penalty cost from the supplier.

In the negotiation case 1, we consider that the manufacturer accepts to split the order (40 units) required in week 6 into two orders. One of 20 units is needed in week 6, which is currently enough for the internal material requirement on the manufacture's side. The other one is composed of 20 units, needed in week 7. The supplier could manage to deliver them using the regular capacity, see Figure 4.11. Accordingly, the supplier has to use subcontracting capacity to produce 20 units and the manufacturer does not charge the supplier for penalty costs (the manufacturer has no penalty cost to pay to his customer).

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	10	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	20	20		40		40	40				40		40	40					
																			20	add 10	add 10											

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1														40														
Firmed Orders					40		40		40			40	40	20	20		40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	20	20	-20	-10	40	40	40	0	0	10	20	20
MO receipt					50		50		50			50		20	30		50		0	50	50					50	50	
MO release			50		50		50			50		20	30		50		50		50					50	50			
																	0	add 50										

Figure 4.11. MRP of the manufacturer in negotiation case 1 in Load variation simulation

The cost on the supplier's side is calculated as (see appendix XI):

Material purchasing cost $MR_{A-\,-}$: $7 \times 60 \times 50 = 21000$ €

Material transportation cost $MT_{A-\,-}$: $50 + 420 \times 2 = 890$ €

Material inventory carrying cost $M_{A-\,-}$: $\frac{25}{52} \times 400 \times \left(50 + \frac{890}{420}\right) = 100$ €

Material Penalty cost $MP_{A-\,-}$: 0 €

Purchasing cost: $PH_{A-\,-} = 21000 + 890 + 100 = 21990$ €

Regular capacity cost PR_{A-} : $(6 \times 50 + 30) \times 10 = 3300$ €

Overtime capacity cost PO_{A-} : 0 €

Subcontracting capacity cost PS_{A-} : $20 \times 40 = 800$ €

Set-ups cost S_{A-} : $7 \times 5 = 35$ €

Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 250 \times \left(\frac{3300+300}{330+20} + 50 + \frac{890}{420}\right) = 75$ €

Product penalty cost P_{A-} : $40 \times (13 - 11) \times 1 = 80$ €

Production cost: $P_{A-} = 3300 + 800 + 35 + 75 + 80 = 4290$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 21990 + 4290 = 26280$ €

Sales SS_{A-} : $360 \times 75 = 27000$ €

Benefit during the horizon:

$N = SS_{A-} - TT_{A-} \quad 27000 - 26280 = 720$ €

Comparing to the normal cases, after negotiation, the supplier earns more benefit than the first normal case since he uses less subcontracting capacity and pays no penalty cost. He earns less benefit than in the second normal case but pays no penalty cost. If the penalty cost is higher than the over cost on subcontracting, the supplier may earn more benefit than in the second normal case.

- Negotiation case 2: the manufacturer confirms his current load and provides extra payment to compensate the supplier's over cost.

If the manufacturer cannot split orders, he may prefer to pay some extra payment to the supplier (usually less than his penalty cost) in order to avoid supplier's delayed delivery, which accordingly protects himself from backlog of material. As a consequence, the supplier has no backorders and may earn some benefits. Based on negotiation, the manufacturer uses some extra payment to avoid paying penalty cost for his customer. Eventually, the manufacturer only needs to pay less, but maintains a good customer satisfaction rate towards his customer.

For instance, in normal case 1, the supplier needs to pay 4991 € for his production cost, including a subcontracting capacity cost of 1600 €, but only earns 24 € for benefit. In normal case 2, the supplier earns 1275 € but pays 120 € for penalty costs. With the extra payment from the manufacturer, the supplier needs to balance his cost/benefits and service rate of deliveries.

In our simulation, such conclusion of the negotiation cannot be reached since the delays from the supplier has no effect on the production on the manufacturer's side, and the manufacturer has no penalty cost to pay even if there are delayed deliveries of material. Therefore, in such case, the manufacturer will probably not agree to pay extra money to the supplier and the supplier will inevitable choose the most beneficial solution for him, even with delayed delivery.

2.4. Price and cycle time

The simulation of price and cycle time negotiation targets on the management of urgent orders, which is not planned in the firm period or flexible period of the forecast. The case we consider is that the current time is period 2.

The manufacturer receives a new order from his customer, with a quantity of 30 units of finished product *A* which needs to be delivered at period 8 (firm period in the manufacturer's received forecast). In period 7, there is only a planned inventory of 5 units, therefore, the manufacturer needs to produce these 30 units (due to the lot size of 10 units) in the beginning of period 4 (1 month of cycle time). Accordingly, 30 units of components *A-1* are needed to be in storage at the end of period 3, but they are not available in the planned stock. As a consequence, the manufacturer has to send an urgent purchasing order of 300 units of component *A-1* at current period 2, and expects the delivery in period 4 (2 weeks of cycle time for the supplier, if he has the raw materials), see Figure 4.12.

MPS

30 urgent

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A																												
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	20	20	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	5	15	25	5
MO receipt									30	0	30	0	30	30	0	30	30	0	30	30	0	30	0	30	0	30	30	0
MO release					30		30		30	30		30	30		30	30		30		30		30	30					

30 urgnet

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1																												
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30					
Projected stock (20)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	30	0	0	0	0	0	0
Net requirement																												
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12								
PO receipt					40		40		40			40	40		40			40		40		40						

Supplier

S&OP

30 urgnet

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40			40		40		40						
Firmed Orders					40		40		40			40																

Figure 4.12. MPS and MRP of the manufacturer in normal case in Price and cycle time simulation

2.4.1. Normal case

- Case 1: the supplier can fulfill the order with the current inventory, there is no extra cost.
- Case 2: the supplier can fulfill the order with his overtime capacity and subcontracting capacity

In this case, the supplier has only an available overtime capacity of 10 units in period 2, the remaining 20 units needing to be purchased from the subcontractor. The supplier calculates his costs for fulfilling the urgent order from the manufacturer, and finds he is losing money. Here, we consider that the supplier has enough material inventories for such urgent orders and we focus on the cost of material purchasing and producing finished product. Therefore, we omit the inventory carrying cost here (see appendix XII):

Material purchasing cost $MR_{A-\_\_}$: $30 \times 50 = 1500$ €

Material transportation cost $MT_{A-\_\_}$: $\frac{50+60\times 2}{60} \times 30 = 85$ €

Material inventory carrying cost $M_{A-\_\_}$: 0 €

Material Penalty cost $MP_{A-\_\_}$: 0 €

Purchasing cost: $PH_{A-\_\_} = 1500 + 85 = 1585$ €

Regular capacity cost PR_{A-} : 0 €

Overtime capacity cost PO_{A-} : $10 \times 15 = 150$ €

Subcontracting capacity cost PS_{A-} : $20 \times 40 = 800$ €

Set-ups cost S_{A-} : $1 \times 5 = 5$ €
Product inventory carrying cost P_{A-} : 0 €
Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 150 + 800 + 5 = 955$ €

The total cost until the week 12 is:

Total cost: $TT_{A-} = 1585 + 955 = 2540$ €

Sales SS_{A-} : $30 \times 75 = 2250$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} \quad 2250 - 2540 \quad - 290 \text{ €}$$

Therefore, he does not accept the urgent order and suggests a new delivery date.

- Case 3: the supplier can fulfill the order using only overtime capacity, with delays

In case 3, the supplier has only an available overtime capacity of 10 units in period 2, the remaining 20 units being possibly produced 2 weeks later with the overtime capacity. The 10 units produced early need to be in stock temporarily for 2 weeks.

Material purchasing cost $MR_{A-\ -}$: $30 \times 50 = 1500$ €
Material transportation cost $MT_{A-\ -}$: $\frac{50+60\times2}{60} \times 30 = 85$ €
Material inventory carrying cost $M_{A-\ -}$: 0 €
Material Penalty cost $MP_{A-\ -}$: 0 €

Purchasing cost: $PH_{A-\ -} = 1500 + 85 = 1585$ €

Regular capacity cost PR_{A-} : 0 €
Overtime capacity cost PO_{A-} : $30 \times 15 = 450$ €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : 2 5 10 €
Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 20 \times \left(\frac{450}{30} + 50 + \frac{170}{60}\right) = 15$ €
Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 450 + 10 + 15 = 475$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 1585 + 475 = 2060$ €

Sales SS_{A-} : $30 \times 75 = 2250$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} \quad 22\,50 - 2060 = 190\ €$$

As a consequence, the manufacturer would not get his urgent supplies as expected and accordingly, urgent orders from the manufacturer's customer would not be fulfilled. Therefore, the manufacturer may earn less money, or may even lose money through finding other solutions to fulfill the customer's urgent orders. As a consequence, negotiation with the customer may be necessary for the manufacturer.

2.4.2. Negotiation case

In the negotiation case, the over costs on the supplier's side is paid by the manufacturer. On the manufacturer side, the costs are as follows:

Material purchasing cost $MR_{A-\ -}$: $30 \times 75 = 2250$ €
Material transportation cost $MT_{A-\ -}$: $50 + 30 \times 2 = 110$ €
Material inventory carrying cost $M_{A-\ -}$: 0 €
Material Penalty cost $MP_{A-\ -}$: 0 €

Purchasing cost: $PH_{A-\ -} = 2250 + 110 = 2360$ €

Regular capacity cost PR_{A-} : $30 \times 20 = 600$ €
Overtime capacity cost PO_{A-} : 0 €
Subcontracting capacity cost PS_{A-} : 0 €
Set-ups cost S_{A-} : $1 \times 5 = 5$ €
Product inventory carrying cost P_{A-} : 0 €
Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 600 + 5 = 605$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 2360 + 605 = 2965$ €

In order to compensate the over cost from the material purchasing, the manufacturer requests a higher price from the customer, 115 €, per unit.

Sales SS_{A-} : $30 \times 115 = 3450$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} \quad 34\,50 - 2965 = 485\ €$$

Therefore, the negotiation would focus on the extra payment from the manufacturer to the supplier for the on-time delivery for the urgent orders. If the manufacturer receives the orders as expected, he gets a benefit of 485 €. However, in order to fulfill the urgent order, the supplier loses 290 €. The ideal negotiation could be sharing benefits: the manufacturer pays the supplier 380 € and has a benefit of 105 €; the supplier receives an extra payment of 380 €, performs on-time delivery and earns a benefit of 90 €.

2.5. Order priority and lot size

2.5.1. Order priority

Let us consider that the supplier is involved into three supply chains and deals with two additional customers *f* and *v*, who order the finished product *A-2* (the same product than *A-1*) and another kind of finished product denoted *A-3*. The orders from the three customers are as shown in Table 4.1. In our simulation, we only present the supply and demand process between the supplier and customer *c* (orders from customer *f* and customer *v* are not specified).

Table 4.1. Customers firmed orders

Order No	Customer	Product	Quantity	Material arrived	Required delivery
C1	*c*	*A-1*	40	Week 8	Week 10
C2	*c*	*A-1*	40	Week 10	Week 12
F1	*f*	*A-2*	40	Week 8	Week 10
F2	*f*	*A-2*	40	Week 10	Week 12
V1	*v*	*A-3*	40	Week 8	Week 10
V2	*v*	*A-3*	40	Week 10	Week 12

For each finished product *A-1*, *A-2*, *A-3*, the routing of production based on different and/or common activities are as shown in Table 4.2.

Table 4.2. Routings of products

Product	Routing		
A-1	Activity 1 (4h)	Activity 2 (4h)	Activity 3 (4h)
A-2	Activity 2 (4h)	Activity 3 (8h)	
A-3	Activity 1 (4h)	Activity 2 (4h)	Activity 3 (4h)

On the supplier's side, there are three workstations: machine 1, machine 2 and machine 3, with their capacity on different activities shown in Table 4.3.

Table 4.3. Machines and related information

Machine	Activity	Capacity	Duration
Machine1	Activity 1	40 Units	4h
Machine2	Activity 2	40 Units	4h
Machine3	Activity 3	40 Units	4h

On the base of these technical data, a possible rule of production scheduling is the highest priority of orders from customer *f*, if we suppose here that the supplier considers customer *f* as more important than the others. For the orders from customer *c* and customer *v*, the supplier has to pay a higher penalty cost for customer *v*. Accordingly, if conflicts exits, orders from customer *c* are likely to be postponed. The scheduling is performed as Figure 4.13 shows.

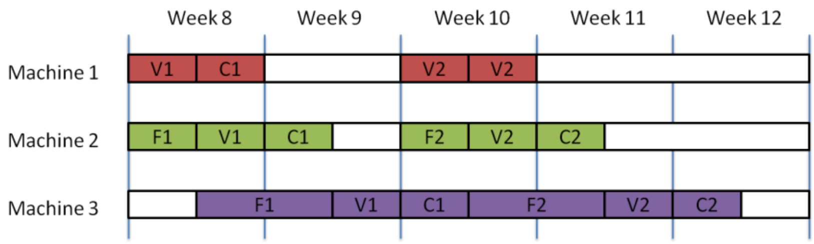

Figure 4.13. The chart of scheduling

In Figure 4.13, it is clear that machine 3 is the critical resource which generates conflicts between orders V1 and C1, and V2 and C2. In order to pay less penalty cost, the supplier decides to delay one order from customer *c*, C1 and C2.

2.5.1.1. Normal case

In the normal case, the supplier has no information about the order priority on both the customer *c* and customer *v*, and as a consequence, decision of order priority is made locally on the supplier's side. The supplier chooses to postpone C1 which should be delivered on week 10 but is delivered actually on week 11, C2 which should be delivered on week 12 but is actually delivered on week 13. Due to the delayed delivery, the manufacturer has to deal with some backorders, see Figure 4.14 (detailed simulation, see appendix XIII).

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	20	20	10	10	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	5	-5	15	35	15	25	35	15	30	15	25	35
MO receipt									30		30		30	30		30	30		30	30		10	30	30		30	30		30		30	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
																		10	add 30													

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	-20	10	0	20	30	0	0	10	10	20	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																		10	add 30	20	add 20											

Figure 4.14. MPS and MRP of the customer *c* (manufacturer) in s normal case in Order priority simulation

Due to the backorders, the penalty costs on the manufacturer's side are:

$$\text{Material Penalty cost } MP_{A-} : 40 \times (11 - 10) \times 1 + 40 \times (13 - 12) \times 1 = 80\,€$$

$$\text{Product penalty cost } P_{\ A}: 20 \times (15 - 14) \times 10 = 200\,€$$

Therefore, the manufacturer has to pay 200 € to his customer but only receives 80 € from the supplier.

2.5.1.2. Negotiation case

In the negotiation case, the supplier receives information about the order priority from the customer *c* and customer *v*. Customer *c* prefers to keep the C1 on time and C2 would be postponed due to a sufficient inventory level. Customer *v* provides information of the possibility to delay V1. Thereby, based on the shared information and negotiation, the supplier re-schedules his production plans and postpones V1 and C2. As a result, for customer *c*, the supplier only postpones C2 which should be delivered on week 12 but is delivered actually on week 13, see Figure 4.15 (for the detailed simulation, see appendix XIV).

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	20	20	10	10	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	5	15	5	25	5	15	25	5	20	5	15	25
MO receipt									30		30		30	30		30	30		30	30		30		30		30	30		30		30	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	0	20	30	0	0	10	10	20	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																				20	add 20											

Figure 4.15. MPS and MRP of the customer *c* (manufacturer) in negotiation case in Order priority simulation

As we mentioned, the penalty cost for customer *v* (4 € per unit, per period) is higher than for customer *c* (1 € per unit, per period). We suppose that for customer *v*, V1 is delayed for one period. Therefore, in the negotiation case, customers have no penalty to pay due to sharing information on order priority. The penalty costs from the supplier, should be:

Material Penalty cost $MP_{A\text{-}}$: $40 \times (13 - 12) \times 1 = 80$ €

Material Penalty cost $MP_{\text{-}}$: $40 \times (11 - 10) \times 4 = 160$ €

Comparing the normal case and the negotiation case, the supply chain loses a total of 280 € for penalty costs in the normal case, but 240 € in the negotiation case. Despite the supplier pays more penalty cost based the shared information of order priority, he maintains a better service rate with no real effects on his customers (customer *c* and customer *v*).

2.5.2. Order grouping

We suppose that due to internal cost or capacity constraints, the manufacturer provisionally needs a larger lot size for being able to group several orders from the customer in order to reduce his total cost.

2.5.2.1. Normal case

- Case 1: the manufacturer makes the grouping without effect on delivery (see appendix XV)

Material purchasing cost $MR_{A\text{-}\ \text{-}}$: $6 \times 60 \times 50 = 18000$ €

Material transportation cost $MT_{A\text{-}\ \text{-}}$: $50 + 360 \times 2 = 770$ €

Material inventory carrying cost $M_{\ A\text{-}\ \text{-}}$: $\frac{25}{52} \times 370 \times \left(50 + \frac{770}{360}\right) = 93$ €

Material Penalty cost $MP_{A\text{-}\ \text{-}}$: 0 €

Purchasing cost: $PH_{A\text{-}\ \text{-}} = 18000 + 770 + 93 = 18863$ €

Regular capacity cost $PR_{A\text{-}}$: $(4 \times 50 + 2 \times 80) \times 10 = 3600$ €

Overtime capacity cost $PO_{A\text{-}}$: 0 €

Subcontracting capacity cost $PS_{A\text{-}}$: 0 €

Set-ups cost S_{A-} : $6 \times 5 = 30$ €

Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 350 \times \left(\frac{3600}{360} + 50 + \frac{770}{360}\right) = 105$ €

Product penalty cost P_{A-} : 0 €

Production cost: $P_{A-} = 3600 + 30 + 105 = 3735$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A-} = 18633 + 3735 = 22368$ €

Sales SS_{A-} : $320 \times 75 = 24000$ €

Benefit during the horizon:

$$N = SS_{A-} - TT_{A-} \quad 24000 - 22368 = 1402 \text{ €}$$

The simulated data in this case are the same than with the normal case 1, scenario 1.1 concerning the periods of forecast. In the previous case, the supplier loses money due to an increase in material purchasing. However, when using a larger manufacturing lot size, the supplier reduces his number of set-ups times, as well as the cost for set-ups. Accordingly, the next material replenishment should be postponed since there is no requirement for material due to the stored finished products in the product inventory (early produced with larger lot size and less set-up times). However, the supplier needs to maintain a higher temporary level of inventory of finished products, with a higher inventory carrying cost.

- Case 2: the manufacturer voluntarily delays some orders, the customer has no inventories and pays penalty costs (see appendix XVI)

Material purchasing cost $MR_{A- -}$: $6 \times 60 \times 50 = 18000$ €

Material transportation cost $MT_{A- -}$: $50 + 360 \times 2 = 770$ €

Material inventory carrying cost $M_{A- -}$: $\frac{25}{52} \times 530 \times \left(50 + \frac{770}{360}\right) = 158$ €

Material Penalty cost $MP_{A- -}$: 0 €

Purchasing cost: $PH_{A- -} = 18000 + 770 + 158 = 18928$ €

Regular capacity cost PR_{A-} : $(4 \times 50 + 1 \times 80) \times 10 = 2800$ €

Overtime capacity cost PO_{A-} : 0 €

Subcontracting capacity cost PS_{A-} : 0 €

Set-ups cost S_{A-} : $5 \times 5 = 25$ €

Product inventory carrying cost P_{A-} : $\frac{25}{52} \times 310 \times \left(\frac{2800}{280} + 50 + \frac{770}{360}\right) = 93$ €

Product penalty cost P_{A-} : $40 \times (14 - 12) \times 1 = 80$ €

Production cost: $P_{A-} = 2800 + 25 + 93 + 80 = 2998$ €

Eventually, the total cost until the week 12 is:

Total cost: $TT_{A\text{-}} = 18928 + 2998 = 21926$ €

Sales $SS_{A\text{-}}$: $320 \times 75 = 24000$ €

Benefit during the horizon:

$$N = SS_{A\text{-}} - TT_{A\text{-}} \quad 24000 - 21926 = 2074 \text{ €}$$

The supplier performs these activities since the benefit he gets is more than his penalties. But the delays do have effect on the following actions on the manufacturer's side (see Figure 4.16). The case shows the typical problems of order grouping with no attention to the due date.

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	5	-15	15	25	5	-10	-25	15	25
MO receipt									30	0	30	0	30	30	0	30	30	0	30	30	0	30	0	10	0	50	30	0	0		60	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
																				10		add 20			0		add 30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	-20	-20	30	0	0	-30	-30	20	-10	-10	-10	-10	-10
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																				0		add 40			0		add 40	0				

Figure 4.16. MPS and MRP of the manufacturer in normal case in Order grouping simulation

2.5.2.2. Negotiation case

After negotiation, the agreed lot size is supposed to be in between the one of the previous cases (supplier adopts 80 units for covering the two coming orders) and the classical lot size (the manufacturer requires 40 units in each purchasing order).

If the manufacturer accepts to receive 80 units for each delivery, there is a temporary increase for his inventory and a related carrying cost. The supplier performs early production using a larger lot size, and delivers the parts shortly after producing, with less inventory carrying cost.

On the other hand, if the manufacturer considers that 80 units for each delivery is less beneficial due to the higher temporary inventory level, the manufacturer may agree to accept 60 units. Therefore, the negotiation on the lot size also needs to balance the related costs.

Afterwards, if the coming orders are confirmed as they are in the flexible period, it is a win-win situation for the supplier and the manufacturer; the supplier using a lower sale price avoids an important finished product inventory cost and the manufacturer spends some material inventory cost to gain a lower purchasing price in return. If the orders are not confirmed, the risk has been shared since the parts were less expensive for the manufacturer: they have both shared benefit and risk.

3. Conclusion of chapter 4

In this chapter, we have shown some numerical simulations of our examples of suggested negotiation processes. For each process, we have compared the normal case(s) and the typical negotiation-based case(s), in order to show that the negotiation processes may lead to a win-win situation, under some conditions. The simulations are very simple but illustrate our main ideas on the proposed negotiation process. Since the real situations may be more complex than the simulated ones, other conditions would surely provide more strict and mature factors for making decisions in the negotiation process.

Chapter 4 provides illustrations of the suggested negotiation processes described in Chapter 3. The simulations gave us an overview on the cost-related constraints of the negotiation process. Through these examples, it is shown how the supply chain member share information, risks, and related costs by publishing constraints or launch protections activities, aiming at achieving win-win situations. If not, negotiations are hardly to reach mutual agreements. Nevertheless, these cases are not common in practice, since they require trustful and reliable relationships between partners. How to identify these suitable relationships is, in our opinion, another critical factor for adopting negotiation processes. Therefore, we shall investigate in Chapter 5 the various types of cooperation situations which may exist between partners, in order to better identify in which cases our negotiation processes seem to be realistic.

Chapter 5
A Model of Cooperation Situations

The analysis of real situations performed in Chapter 2 shows that cooperation in supply chains is a very complex issue, with a lot of differences between theoretical frameworks as listed in chapter 1 and a more complex and confusing industrial reality, illustrated in chapter 2. Based on some practices identified from the case studies, we have suggested that negotiation processes considering interests of both the supplier and the customer could help to obtain a better cooperation. However, many authors emphasized that other issues than purely technical ones define a relationship, like trust, maturity, involvement, goodwill etc., which are important factors for negotiation. Therefore, in this chapter, we suggest a taxonomy of the cooperation situations, based on what we consider as the most critical and widely used factors influencing cooperation. As a second step, we try to match the identified situations with each negotiation process described in Chapter 3, in order to show the situations required for making the suggested negotiation process realistic in practical cases.

1 Literature view on the definition of cooperation situations

Information sharing, joint-planning, cooperation and strategic partnerships over the entire supply chain are now universally considered as conditions for building more efficient and reactive supply chains. Therefore, how to synchronize local activities through global processes is an actual difficulty that supply chain members have to face. Substantial efforts have been described in the literature on the technical aspects that help supply chain members to cooperate using different tools, management strategies and practical methods, as Chapter 1 mentioned. On the other hand, supply chains have more and more complex structures, and may involve partners from different domains, sizes, countries, accordingly from different cultures. In that context, it is widely recognized that the performance of the supply chain cooperation is not only a technical matter, but is also concerned with behavioral issues (Möllering, 2003). As a consequence, the qualitative factors conditioning the cooperative relationships between partners are object or an increasing attention from both academics and practitioners.

1.1 Cooperation in Supply Chains: beyond the technical view

Firms are increasingly building cooperative relationships with their supply chain partners in order to achieve efficiency, flexibility, and competitive advantages (Nyaga et al. 2010). Many studies suggest that cooperative relationships are associated with the improvement of the performance of the supply chains (Heide and John, 1990; Ganesan, 1994; Kalwani and Narayandas, 1995; Cannon and Perreault, 1999). Kalwani and Narayandas (1995) note that manufacturers seek for long-term relationships with fewer suppliers to secure valued resources and technologies, harness supplier skills and strengths, and gain from quality and process improvements. Holland (1995) has shown that companies are moving towards cooperative relationships in an effort to make the supply chain as a whole more competitive. Maloni and Benton (1997) suggest that it is essential for a firm's survival to have cooperative relationships with its suppliers. Chung et al. (2005) state the idea that one way to build an efficient supply chain is to integrate the supply chain activities by developing cooperative relationships between firms. Daugherty et al. (2006) found that firms engaged in cooperative relationships achieved improved visibility, higher service levels, increased flexibility, greater end-customer satisfaction, and reduced cycle times.

It is therefore often considered in the literature that customer-supplier relationship plays an important role in the performance of supply chains. Accordingly, substantial works target on the quality and measurement of customer-supplier relationship by specifying the positive or negative factors influencing cooperation. Within this literature, some studies have suggested taxonomies of those relationships. In the following section, we are going to introduce some popular and widely used factors influencing customer-supplier relationship, as well as the existing taxonomies on the field.

1.2 Influencing factors

Customer-supplier relationships have been undergoing massive changes at national and international levels (Bidault et al., 1998; Tan, 2001; Zheng et al., 2007; Giunipero et al., 2008; Soosay et al., 2008). Esposito and Passaro (2009) consider that these changes relate to the object of transaction between customer and supplier (from parts to components, then to complex systems); the firm's functions in the supply relationship (production, but also design, planning, marketing...); the supplier's skills as required by the customer (not only technical but also managerial or related to logistics,); and the level of trust and cooperation which sustains these relationships. Many other authors have investigated the various kinds of factors influencing supply chain relationship, sometimes summarized by the concept of "relationship atmosphere" (Hallén and Sandströn, 1991). For Andersen and Kumar, (2006), the "relationship atmosphere" addresses six specific dimensions: power/dependence balance, trust/opportunism, understanding, cooperativeness/competitiveness, closeness/distance, and commitment. More precise frameworks have also been suggested; for instance, a total of eighteen key "relationship indicators" have been identified by Meng (2010). The "top 10" relationship indicators are trust, objectives, teamwork, risk allocation, communication, continuous improvement, business attitude, problem solving, procurement system, and senior management commitment.

Table 5.1 suggests a brief summary of the concepts identified in a panorama of the literature. Even if many other articles can of course be found on the subject, we do think that these ones are already quite representative and give a quite comprehensive view on the subject. Trust, commitment, dependency and power are therefore the concepts most often considered by the authors interested in qualitatively analyzing the relationships between Supply Chains members. Among these factors, power and trust are often considered and are usually seen as the main factors driving the relationships in the supply chains. They will be analyzed in more details in the next sections.

1.2.1 Power

Power is often considered as a way to mitigate risks. As confirmed in real situations described in Chapter 2, risks in supply chains are usually associated either to product demand or to product supply, due to capacity limitations or supply disruptions (Johnson, 2001). Indeed, to limit such risks, the first solution for the customer is to “control” the supplier, since control mechanisms may reduce opportunistic behaviors (Liu et al., 2010). Control requires power and the relative power of an organization over another is the result of the net dependency of the one on the other (Caniëls and Gelderman, 2010).

Table 5.1. Factors influencing supply chain relationships in the literature

Authors & Year		**Atmosphere**	**Attitude**	**Closeness/ Distance**	**Commitment**	**Common Purpose**	**Common Understanding**	**Communication**	**Culture**	**Dependency**	**Goodwill/ Cooperativeness**	**Information sharing**	**Opportunism**	**Power**	**Trust**
Carter and Jennings	2002				√										√
Johnston et al.	2004									√					√
Fynes et al.	2005				√			√		√					√
Benton and Maloni	2005													√	
Andersen and Kumar	2006	√		√	√		√			√	√		√	√	√
Ireland and Webb	2007									√				√	√
Su et al.	2008	√						√							√
Zhao et al.	2008				√									√	
Narasimhan et al.	2009									√				√	
Nyaga et al.	2010				√							√			√
Hausman and Johnston	2010				√										√
Liu et al.	2010		√		√								√	√	√
Ren et al.	2010				√			√		√		√			
Lee et al.	2010				√					√					√
Meng	2010		√			√		√							√
Cheng	2010								√						√
Total		**2**	**2**	**1**	**9**	**1**	**1**	**4**	**1**	**7**	**1**	**2**	**2**	**6**	**12**

➢ *Power description*

According to Belaya and Hanf (2009), power is often referred to as the “ability” or “capacity” to do something in the psychological context. They furthermore specify that this ability or capacity is used for modifying the behavior of other individuals or organizations. For instance, Dahl (1957) defines power as follows: “A has power over B to the extent that he can get B to do something that B would not otherwise do”. Emerson (1962) defines power as the ability of one firm to influence the intentions and actions of another firm and Ratnasingham (2000) refers to it as the capability of a firm to exert influence on another firm to act in a prescribed manner. Power is therefore linked to behavior. Lewin (1951) states that the power of person A over person B is determined in terms of the force A could bring to bear on B and the resistance B could offer. Mathematically, the power of A over B is defined as “the quotient of the maximum force that A could (or possibly could) induce on B and the maximum resistance that B could offer”. Homans (1974) also states that A’s power over B is the extent to which A can affect B’s behavior (through exchange).

Many other definitions could be found and quoted with various points of views. The examination of all these definitions of power from different perspectives allows to conclude that power generally refers to the ability, capacity or potential to get others do something, to command, to influence, to determine or to control the behaviors, intentions, decisions or actions of others in the pursuit of one's own goals or interests against the will of the power target, as well as to induce changes, to mobilize resources, or to restructure situations.

- *Power source*

On the other hand, some works have concentrated on tracing the source of power in order to better understand the influence of power on customer and supplier relationship. Reward and coercive attitudes, early introduced by French and Raven (1959), remain the clearest and most widely recognized of such power sources, indicating the ability of the powerful partner to mediate dividends (such as increased business or shared benefits coming from cost reductions) or punishment (such as decreased business or dictated cost reductions) to the target. Reward power depends on the ability of the power holder to offer rewards to others (Zhao et al., 2008; Liu et al., 2010). Coercive power enables an individual to punish others.

Beyond such traditional considerations, other sources of power may also have a prominent role in the supply chain (French and Raven, 1959; Rawwa et al., 1997; Yeung et al., 2009). "Expert power" derives from skills or special knowledge in a specific subject, or refers to the perception that one firm holds information or expertise (such as product or process leadership) that is valued by another firm. "Referent power" implies that one firm desires identification with another for recognition by association, or depends on an ability to be attractive to others and on the charisma and interpersonal skills of the power holder. "Legitimate power" stems from a legitimate right to influence, and an obligation to accept this influence, which include both its traditional (inherent) and legal forms; it represents the final two power bases and infers that the target believes in the right of the source to wield influence (such as via a sales contract) (Maloni and Benton, 2000; Flynn et al., 2008).

To facilitate power exploration, many researchers have attempted to get a simplified view through dichotomization of the different power sources into categories, such as coercive/non-coercive (Cather and Howe, 1989; Kim, 2000; Hu and Sheu, 2005), mediated/non-mediated (Brown et al., 1995; Zhao et al., 2008), coercive-mediated/ reward-mediated (Benton and Maloni, 2005), and economic/non-economic (Belaya and Hanf, 2009) (see Table 5.2). Coercive sources of power arise from punishment, while non-coercive sources arise from rewards or high quality assistances. Mediated power represents influencial efforts that are deliberately engaged (or threatened) by the power source to guide target response, including coercive, reward, and legal legitimate bases. Non-mediated power sources (expert, referent, and legitimate resource) are not specifically exercised or threatened to manipulate the target.

- *Power & Dependence*

Since power is related with influence and decision control among partners, understanding power requires to understand the issue of dependence. Quite a few researchers have used in their study the concept of dependence in order to conceptualize power (see for instance (Kale, 1986); (Kim et al., 2004); (Bunduchi, 2007)). In the study of Kale (1986), dependence is defined as the degree to which the target firm needs to maintain its relationship with the source in order to achieve its desired goals. Kim et al. (2004) state that power fundamentally resides in the dependence of one actor on another. Bunduchi (2007) also views power in terms of dependence and access to critical resources. Belaya and Hanf (2009) suggest a more precise relationship between power and dependence: they state that although both actors are mutually dependent in an exchange, it does not mean that they are always equally dependent on each other. The less dependent actor will maintain a power advantage, resulting in a power imbalance. In essence, asymmetric dependence between two actors in an exchange relation constitutes the essence of the concept of power dependence

Table 5.2. Dichotomization of power resource (Belaya and Hanf, 2009)

Coercive		**Non-coercive**
Coercive	VS	Expert Legal Legitimate Referent Reward Traditional Legitimate
Mediated		**Non-mediated**
Coercive Legal Legitimate Reward	VS	Expert Referent Traditional Legitimate
Economic		**Non-economic**
Coercive Reward	VS	Expert Legal Legitimate Referent Traditional Legitimate
Coercive-mediated		**Reward-mediated**
Coercive Legal legitimate	VS	Reward Expert Referent Traditional Legitimate

Therefore, dependence is also widely studied in order to better understand its relation to power (Narasimhan et al., 2009). According (El-Ansary and Stern, 1972), dependence between two firms is a function of three elements. Firstly, the percentage of one Firm A's business conducted with a Firm B and the proportion of Firm A's profit contributed by Firm B. Secondly, the commitment Firm A has to Firm B in terms of the latter's marketing strategies. Thirdly, the difficulty in effort and cost faced if either firm decides to exit the relationship. A balanced inter-dependency is considered as the extent to which supply chain partners believe that their business relationship is necessary. As inter-organizational interdependency increases, the need for coordination, cooperation and collaboration also increases and information sharing becomes more important (Mentzer et al., 2001).

Besides, authors have argued on the advantages brought by power. For instance, non-coercive power provides numerous relational advantages, including the ability to overcome lack of consensus and reach fast decisions, promote innovation and change to address environmental opportunities and threats (Cox, 2001), influence the adoption of advanced information technologies (Hart and Saunders, 1997), and provision of legitimacy and stability to a network (Oliver, 1990). On the contrary, Ireland and Webb (2007) suggest that power differentials between partners create opportunities for more powerful firms to act opportunistically by exercising coercion.

- *Power in supply chains*

Based on the general definition of power, its sources and relationship with dependence, power is a multi-dimensional construct encompassing an influence that can be used to evoke desired actions from partners (Ireland and Webb, 2007). Particularly in supply chain relationship research, power has been defined as the ability of one member of a supply chain to influence or control the decisions and behavior of other persons, groups, or organizations (Payan and McFarland, 2005). The ability of one supply chain member to fulfill another supply chain member's goals is one of the possible foundations of power. Nevertheless, power retains the potential to upset the mutuality of supply chain relationships and subsequently presents a barrier to the win-win integration process (Maloni and Benton, 2000; Benton and Maloni, 2005). For many authors, mutual dependence and power appear to be foundations of a cooperative relationship, allowing to develop and maintain long term relationship (Narasimhan et al., 2009; Cheng, 2010).

In supply chain relationships, one party may decide to reduce its dependence on the other; however, strategic partners may accept dependence as a trade-off for the benefits that accrue from such relationship. If power and dependence are asymmetrically distributed, the relationship will not only be difficult to manage, but the benefits for the most dependent firm will be hardly realized, which may encourage opportunistic behavior (Easton, 2002; Cousins, 2002). Coercive power may not be sufficient in uncertain environments. In case of uncertainty, more initiative is expected from partners in order to cope with unexpected events or situations, and initiative seldom comes from a controlled partner. As a consequence, companies try to develop trust and commitment at their partner's, which may lead to better performance when dealing with uncertainties. Nevertheless, the power-dependence dimension cannot be ignored when seeking to evaluate strategic supply chain relationships, but needs to be addressed as a multi-dimensional concept (Johnsen et al., 2008).

1.2.2 Trust

The customer can try to cope with the risks linked to the necessity to synchronize actions with its suppliers by dependence and power, while keeping a clear distance with them. This strategy is called "arm's length relationship" in the literature, and can be compared to the "formal contracted rules and procedures" considered by Williamson (1985). Many works have addressed that traditional arm's length relationship is efficient in stable environments, but not sufficient to face unstable and uncertain situations (Heide and Jogn, 1990; Gadde and Snehota, 2000). As a consequence, trust and commitment are necessary when uncertainties occur, since all the cases of cooperation cannot be listed in the contract, or even cannot be controlled.

- *Trust description*

Trust is defined as the confidence in the reliability and integrity of the other party, and the ability to predict the actions of the other party in the relationship, as well as the belief that the other party will not act opportunistically (Anderson and Narus, 1990; Morgan and Hunt, 1994). Moorman et al. (1993) define trust as the willingness to rely on an exchange partner in whom one has confidence. Ganesan (1994) states that trust refers to the extent to relationship which partners perceive each other as credible and benevolent. Sako and Helper (1998) consider trust as an expectation held by an agent that its reading partner will behave in a mutually acceptable manner. Trust implies an expectation or an attitude; it occurs gradually in the interaction of both parties (Su et al, 2008). Lee et al. (2010) define trust as the extent to which firms believe that supply chain partners will fulfill their responsibility to each other in good faith.

According to Sako (1992) and Fynes et al., (2005), three types of trust may be distinguished: contractual trust, competence trust and goodwill trust, based on keeping promise, confidence in partner's competence and commitment to maintain a trading relationship. With contractual trust, each party adheres to specific written or oral agreements. Competence trust is built on each other's capabilities to carry out their tasks. When goodwill trust is reached, the parties express their willingness to do more than what is formally expected. Two dimensions of trust are also discussed in (Johnston et al., 2004): trust as the belief that the other party is dependable or reliable on one hand, and belief that the other party would act in the best interest of his partner even if there is no way to check it on the other hand.

➢ *Trust, Commitment and other related factors*

Trust is usually considered as linked to specific behaviors. The most widely mentioned one is commitment. Some researchers propose that trust contributes to commitment by contributing to joint actions (Anderson et al., 1994; Reichheld, 1996). Authors state that commitment entails vulnerability, and parties may only cooperate with trustworthy partners (Hallen et al., 1991). Morgan and Hunt (1994) define commitment as a partner's belief that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it. These statements indicate that commitment and trust are closely related. Morgan and Hunt (1994) find that opportunistic behavior also results in decreased relationship commitment through the mediating effect of trust, where a party in a dyadic exchange relationship becomes less committed to the relationship as it loses trust in the other party.

We can see that authors sometimes use different concepts to interpret quite similar statements, but in most of the identified studies, the preponderant importance of confidence, trust, commitment and benevolence for cooperation is underlined, these different notions expressing the level of perception of the supply chain member's about the dependability and reliability of the other members (Hausman and Johnston, 2010), based on their capability, actions and behaviors. This perception undoubtedly affects the level of commitment, informal agreement, willingness to cooperate, communication, information sharing, opportunistic actions and certainly operational processes (Carter and Jennings, 2002; Johnston et al., 2004). For instance, some works indicate that trust is a deterrent to opportunistic behavior. When trust is embedded in the relationship, opportunistic behavior is unlikely to occur because partner firms eschew short-term individual gains in favor of the long-term interests of the partnership (Beamish and Banks, 1987). Trust reduces opportunism in downstream supply chains (Cavusgil et al., 2004), improves supply chain responsiveness (Handfield and Bechtel, 2002), and increases the potential for beneficial supply chain alliances (McCutcheon and Stuart, 2000). Some other authors augured that trust is at best an adherence to the contract, and may be undermined by opportunistic behavior (Meng, 2010). Empirical findings suggest that trust enhances a partner's willingness to cooperate (Wiertz et al., 2004). Information sharing is quite commonly considered as an essential condition for making trust possible, allowing therefore to maintain long term and collaborative supply chain relationship (Nyaga et al., 2010; Ren et al., 2010). The study described in (Lee et al., 2010) shows that trust has a significant positive effect on operational and strategic information sharing, as well as on operational and strategic cooperation, accordingly reducing uncertainty and risk increases.

- *Customer's trust and supplier's trust*

According to Ryssel and Ritter (2000), customer's trust is the extent to which a customer believes that the supplier is honest, benevolent, and competent. Customers trust their suppliers' reliability, i.e. they believe that the supplier stands by its word, fulfills promised role obligations, and is sincere. Customer trust has for instance been addressed by MacKenzie (1992) who demonstrated that customer trust is influenced positively by customer perception of product and service performance, which may be measured through operational activities.

In reverse, supplier's trust in the customer is based on the supplier's observation of customer's dependability and benevolence (Johnston et al., 2004). Suppliers trust their customers, primarily through the contract which binds them, which also represents an important source of trust from the customer to his supplier (MacDuffie and Helper, 2006). The repeated interactions between customer and supplier are also a factor which enables the supplier to develop trust in the customer (Jap and Anderson, 2003). As such, customer's trust can serve as antecedent of supplier's trust (Zhang et al., 2010).

An important reason for unsuccessful relationships is the lack of trust between the partners. The establishment of trust is considered as the basic requirement for long-term successful relationships by both researchers and practitioners (Walter et al., 2002). Development of trust enhances later cooperation within the relationship that ultimately influences performance (Rodriguez and Wilson, 2002; Johnston et al., 2004). In B2B (Business To Business) relationships, trust can influence the behaviors of both parties involved in a relationship. Partnership will be further developed only when trust is sufficient. The higher the degree of trust, the easier the development and maintenance of the partnership will be (Su et al., 2008). Corsten and Kumar (2005) suggest that trust results in greater openness between suppliers and retailers and thus greater knowledge and appreciation of each other's contribution to the relationship. Trust is important in achieving behavioral and performance objectives in inter-firm partnerships, especially in cross-border relationships where hierarchical control may not be viable (Cheung et al., 2010).

1.2.3 Interaction between factors

The precise depictions of influencing factors and their inter-relationships have shown that Trust/Commitment, Power/Dependency are often considered as the most fundamental factors when addressing the relationship in supply chains. Indeed, commitment is clearly seen as a consequence of trust, while dependency proceeds from the partner's power. Additionally, trust and power are often considered as the basic pillars of relationship, which influence many of the other listed aspects, like commitment, cooperativeness, opportunism, etc. Therefore, the identification of the links between trust and power, the most basic and important factors of the relationship, will help to specify a global picture of the interaction between different influencing factors.

According to Ireland and Webb (2007), trust and power exist as different means through which a firm seeks to promote desired behaviors in a partner. Trust and power are complementary and opposing components of social behavior. The complementary nature of trust and power extends from the ability of one to substitute to the other when one fails to achieve desired results. Hémont et al. (2010) suggest that trust is often seen as an alternative to power, since trust decreases the required level of monitoring of the relationship and is an antecedent to cooperative behavior. However, there are constraints in such complementary or alternative relationship. For instance, coercive power and goodwill trust hardly exist simultaneously in customer and supplier relationship, and other forms of trust may concurrently exist with coercive power at any point in time. Similarly, non-coercive power may exist at the same time as goodwill trust, as well as other forms of trust. It is also possible that an excessive use of either non-coercive or coercive power may undermine trust in a relationship (Ireland and Webb, 2007). We have seen some good examples of this in the case studies in chapter 2.

In our opinion, trust and power are rather antagonist concepts, but are nevertheless loosely attached in a dynamic independence. Therefore, the identification of the dynamics between trust and power is definitely important for analyzing the relationships in supply chain, as well as the cooperation situations.

1.3 Cooperation taxonomies

Suggesting classifications is a common way for better understanding complex phenomena. Since the types of relationships between partners of a supply chain do influence the performance of the chain, several taxonomies have been suggested in the literature for different kinds of purposes. Since these types of relationships clearly condition the applicability of the negotiation processes suggested in Chapter 3, we shall analyze these classifications in the newt sub-sections.

1.3.1 Möllering's taxonomy

On the base of 196 cases, and considering trust and performance as discriminating factors, Möllering (2003) defines three clusters of partners based on trust and performance.

The first type of partners (Cluster 1) is called “traditional wary traders”. It represents more than half of the respondents (55.6%) in the database. They display much lower levels of trust and performance than the respondents in the other two clusters.

“Committed flexible partners” is the label given to Cluster 2 representing 30.1 of the sample. These partners have very high levels of trust and performance. Strong reciprocity means that they are very likely to see their suppliers as partners with whom they have mutual interests.

The third cluster is described as “controlled routine partners”. Like the committed flexible partners before, this group of buyers (14.3%) is characterized by high trust and performance (including reciprocity) and they can therefore be called “partners”. The difference is, however, that the partnership relies heavily on formality and strict following of agreed terms. The exchanges between buyer and supplier are very much like a highly reliable but unstoppable routine. Figure 5.1 shows a graphic representation of cluster characteristics.

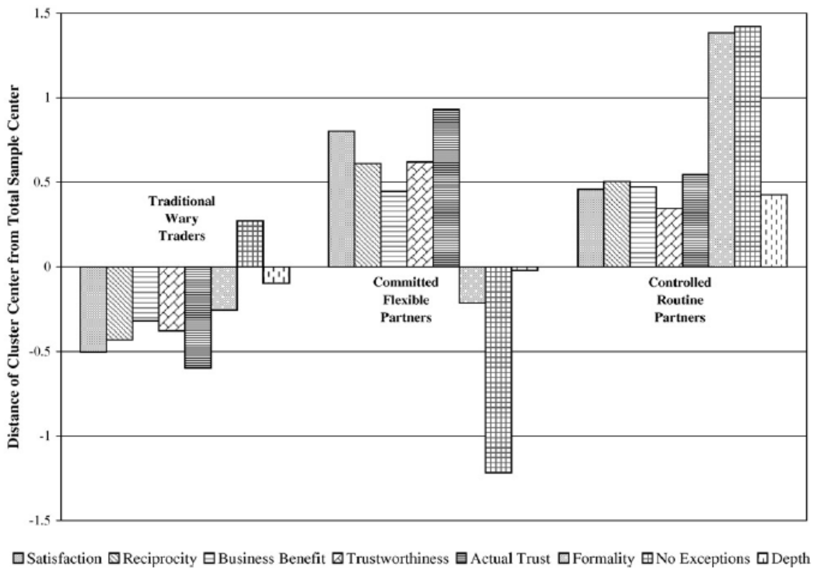

Figure 5.1. Taxonomy from Möllering (2003)

Nevertheless, the independence of the two factors trust and performance may be set into question, since performance is considered as being linked to trust by many authors (Andersen and Kumar, 2006; Johnston et al., 2004; Möllering, 2003).

1.3.2 Hallikas's taxonomy

Hallikas et al. (2005) suggest a classification of supplier relationship built after a questionnaire (see Figure 5.2). The classification is based on the concept of dependency risk: buyer dependency risk (low or high) and supplier dependency risk (low or high). Buyer dependency risk is measured through the value added to the customer and the replaceability of the supplier in the relationship. Supplier dependency is similarly measured through the hold-up and demand risk of the supplier.

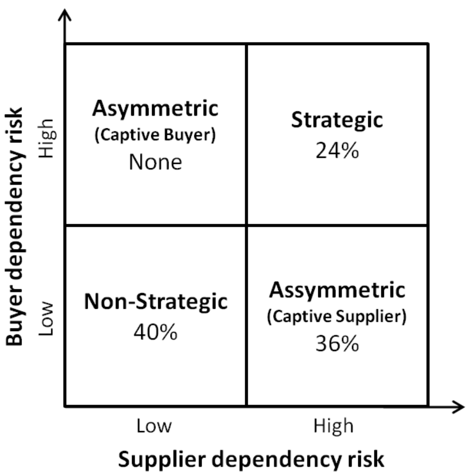

Figure 5.2. Taxonomy from Hallikas et al. (2005)

The authors state that the higher the mutual dependency, the stronger the exploitation of cooperation practices of risk management and learning. When the dependency is asymmetric, and when the relationship is not so strategic, cooperation risk management has a remarkably weaker role. Accordingly, they defined four types of relationships: strategic relationship, non strategic relationship, captive buyer, and captive supplier. After analyzing 42 questionnaires, the theoretical "captive buyer" category was still empty, showing of course the usual power of the buyers, or their reluctance for building such unfavorable relationship.

1.3.3 Marcotte's taxonomy

A classification close to the previous one is suggested in (Marcotte et al., 2009), based on the supply chain's power on the company (low or high) and the company's power on the supply chain (low or high) (see Figure 5.3), introducing the idea that power of A over B may be independent from power of B over A. The taxonomy considers the integration of a partner in the chain, but not a simple point-to-point buyer-supplier relationship as in (Hallikas et al., 2005). Moreover, the definition of the categories gives additional information.

A partner is strategic when the supply chain and the company power are balanced; there is a mutual interest to cooperate. This case is usually considered as the ideal one for building a collaborative link (Geyskens et al., 1996). Nevertheless, the relationship may be difficult to build, since it has to be based on mutual respect and none of the partners can impose its methods to the other.

A partner is dependent when his power over the chain is inferior to the supply chain power over him. Therefore, the chain may impose its constraints on this partner. This situation remains very ambiguous: for many authors (and for large companies), it is the perfect situation since the large companies, who are often the focus partners of the supply chain, can influence their smallest partners by imposing them "good" practices and tools (Vaaland and Heide, 2007; Harland et al., 2007). On the other hand, many authors notice that power prevents the growth of trust, leading only to an appearance of adoption of the new practices (Johnson et al., 1990; Skinner et al., 1992, Brown et al., 1995; Thakkar et al., 2008; Hémont et al., 2010).

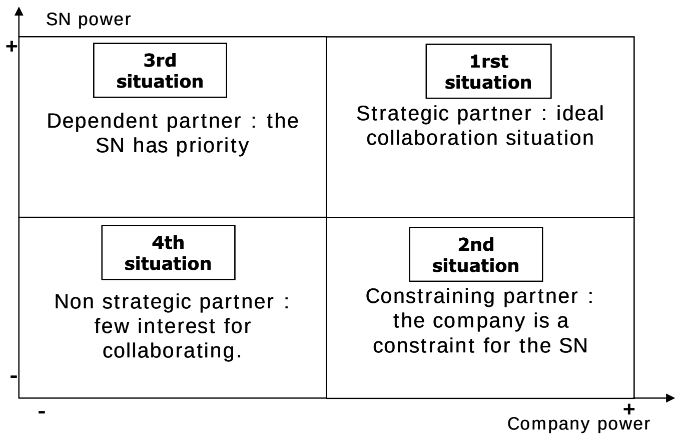

Figure 5.3. Taxonomy from Marcotte et al. (2009)

A non strategic partner is involved in a relationship in which both power and involvement are low. The partner is independent from the chain, and vice versa. In that case, each entity has an opportunistic behavior, which does not allow the emergence of a collaborative relationship (Liu et al., 2010).

A constraining partner is a supplier whose power over the chain is superior to the supply chain power over him. This kind of partnership is described in (Hallikas et al., 2005) on the customer's side as a "captive buyer". In that case, the constraints set by the supplier should be taken into account by the chain. This case, which can often be met in real industrial situations, is poorly compatible with theoretical practices described in Chapter 1.

On the base of this taxonomy, different models of cooperation are suggested in (Marcotte et al., 2009), showing that the links between objectives, constraints and decision variables of the company and of the supply chain (represented by the customer) may vary according to the identified situations.

1.3.4 Liu's taxonomy

Another typical taxonomy is presented in Liu et al. (2010) aiming at the measurement of relationship quality (see Figure 5.4), based on two axes: trust and commitment, with two levels, high and low. Four types of relationship are therefore defined.

Type I (high level trust and high level commitment) is a "buddy" relationship, meaning that both parties in an exchange relationship have close ties, a willingness to sacrifice their own interests for long-term common interests, and a commitment to long-term cooperation.

Type II (high trust and low commitment) is a "relier" relationship. A "relier" means that both parties in an exchange relationship may be willing to sacrifice their own interests for long-term common interests to some extent, but for some reason they are not willing to commit to long-term cooperation.

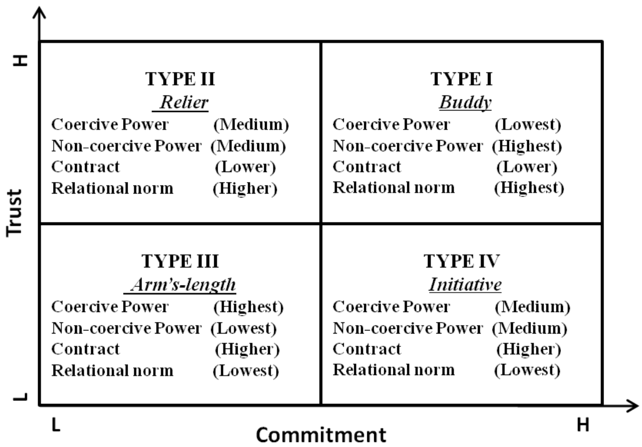

Figure 5.4. Taxonomy from Liu et al. (2010)

Type III (low trust and low commitment) is an "arm's-length" relationship. As already stated, arm's-length means that both parties will have low levels of mutual trust and commitment. Parties in such a formal relationship care little about their partner's feelings, are unwilling to sacrifice their own interests, and do not wish for long-term cooperation.

Type IV (low trust and high commitment) is an "initiative" relationship. An "initiative" means that both parties will be willing to maintain long-term relationships, but mutual trust between them has not yet been established.

These four distinct contexts are coupled with control mechanisms involving both coercive and non-coercive power in order to achieve better coordination between the partners. Nevertheless, the independence of the two axis of the suggested model again remains questionable: indeed, many authors agree on the fact that trust and commitment are closely linked (see for instance (Andersen and Kumar, 2006; Essig and Amann, 2009; Hémont et al., 2010)).

1.3.5 Synthesis of these taxonomies

The existing taxonomies described above again show that many authors consider Trust/Commitment and Power/Dependency as critical factors for the research on relationships in supply chains. In the various types of relationship shown by these taxonomies, other influencing factors can be introduced thanks to their interaction with Trust/Commitment and Power/Dependency, such as willing of cooperation, degree of information sharing, balance between local decision making and global objectives. In that context, it seems that taxonomies based on Trust/Commitment or/and Dependency/Power are able to provide an overview on the customer-supplier relationship, since these factors are fundamental elements which could allow to assess the others.

To be more precise, some taxonomies focus on identifying one influencing factor on both customer and supplier side, such as Hallikas' taxonomy suggests to concentrate on the risks due to dependence, or Marcotte's taxonomy targets the distribution of power in the supply chain. Nevertheless, using one simple influencing factor may be insufficient to identify complex and various customer and supplier relationships. For instance, if non-coercive power or mutual dependence exists in the supply chain, other factors, like the level of trust, or degree of information sharing, will play an important role in order to differentiate various types of relationships. Some other taxonomies provide two axes (such as trust and performance in Möllering's taxonomy, trust and commitment in Liu's taxonomy) in order to better describe different type of relationship, which appear to be more fruitful than concentrating one single factor. However, the relationship or dependence between the two axes is questioned by the works of other authors, since the used pairs of factors, trust and performance, trust and commitment are often considered as closely linked. For instance, trust contributes to commitment; a good commitment relationship requires a well built trust construction. Taxonomies of relationship should preferably be based on influencing factors considered as independent or loosely linked. In addition, the measurement of the adopted factors is currently limited to "high" and "low". Such rough categories may not be sufficient for describing complex phenomena. For instance, power can be on the side of the supplier, on the side of the customer, or balanced, leading to at least three categories. The number of levels could still increase if the strength of the power is considered. Therefore, the levels of the adopted factors may require additional precision in order to describe more complex situations.

Using the existing taxonomies, we have tried to categorize the situations observed in chapter 2; however it appeared as difficult to identify and explain some of the cases we have encountered. Therefore, we believe that some new elements should be added to the exiting taxonomies in order to better model complex cases. Details will be introduced in the next section.

2 A model of cooperation situations

The model of cooperation situations that we suggest aims at describing more precisely different cooperation situations in supply chains, according to various types of customer-supplier relationships. As mentioned in Chapter 2, cooperation between supply chain members is not only technically oriented; behavioral issues based on customer-supplier relationship are essential to be taken into account.

2.1 Bases of the suggested taxonomy

2.1.1 Dimensions

According to the panorama of the literature summarized in Table 5.1, Trust, Power, Dependency and Commitment are the concepts which seem to be the most widely used for explaining the relationships between partners in Supply Chains. As discussed above, trust and commitment are considered as linked by most authors. Similarly, power and dependency are the two opposite sides of the same phenomenon. Besides, from the limitation of existing taxonomies, it seems more meaningful to define a taxonomy based on multiple factors by choosing rather independent ones. On the other hand, the real situations observed in Chapter 2 have shown us that conflicts in customer and supplier relationship may be linked to the dynamics of trust and power. For instance, a more powerful customer could build a trustful foundation with its supplier through supplier development program, or may force his supplier to accept his constraints, which will reduce the supplier's trust on the customer.

Therefore, as a first step, we have chosen to consider two influencing factors, object of a relative consensus: trust and power, and try to analyze the dynamics of relationships based on these two factors. From the literature view and existing taxonomies, and also looking at the real observed situations, it seems that trust and power are the most foundational and widely used factors, which can be considered as rather independent, or at last loosely attached. Other factors, such as commitment, information sharing, opportunism, etc. are closely influenced or related with trust and power. In that context, we believe that a taxonomy with the two dimension of trust and power is a good candidate for identifying and analyzing the supply chain relationship, as well as for positioning the conflicts and dysfunctions towards operational activities.

Concerning the number of levels to consider, we do think that the usual categories "low/high" are not sufficient for describing complex phenomena. For instance, a customer may have no specific feeling towards its supplier. Similarly, the distribution of the power between customer and supplier may be balanced or unbalanced. It is also possible to subdivide the mentioned categories by more than the traditional two degrees (low/high) of the factors, etc. As a consequence, the number of considered levels will be increased. In order to better justify the categories we have chosen for the included factors, we will address them separately and try to link them to real observed situations.

2.1.2 Categories of Power

At least three different cases should be distinguished for describing the power: the customer holds power over its supplier; the supplier is more powerful than the customer; there is a balanced distribution of power between customer and supplier.

Many works in the literature of supply chains concentrate on customer's power over supplier, since customers have usually a dominant status in the customer-supplier relationship. Customer power is considered as the ability of a customer to influence the decisions of a manufacturer in a supply chain (Brown et al., 1983, 1995; Goodman and Dion, 2001). Power at the customer's side has links with resource dependence and resource allocation (Christensen and Bower, 1996). Customer power can be divided into different types (French and Raven, 1959), and each type of customer power impacts other factors, like trust, and furthermore influences the customer and supplier relationships. Nevertheless, power at the supplier's side seems to be seldom considered in literature, but is described in some real applications (Marcotte et al., 2009). We have seen some cases in Chapter 2 where the supplier has a dominant position in the supply chain relationship, due to his competence on some techniques that can be hardly replaced.

Aiming at making the proposed taxonomy clear and understandable, we are going to consider these three cases as our categories of power.

2.1.3 Categories of Trust

Trust between customer and supplier may lead to three main situations: distrust, indifferent feelings and trust. As power, trust is for us an asymmetric factor, since customer and supplier may have different criteria for giving their trust to their partner.

For instance, the customer is more oriented on operational activities, such as quality of product, purchasing cycle time, service performance etc., while the supplier has more consideration on the contract, interaction with his customer and whether the customer trusts him or not, as well as the degree of customer's trust. Therefore, it can be interesting to separately discuss the trust at the customer and supplier sides.

2.2 Description of the model

In the context of our two dimensions and their suggested categories, we propose a taxonomy of relationships between customer and supplier shown in Figure 5.5. In the dimension of power, the categories are stated as "the supplier depends on the customer", "the customer depends on the supplier" and "mutual dependency". Concerning the dimension of trust, the major categories are "distrust", "indifference", and "trust". Since trust may be considered as nonsymmetrical according to different authors, we suggest to describe the taxonomy by two separated figures, one describing the supplier's side, the other the customer's side, in order to be able to represent more complex situations. For instance, a situation in which the customer depends on the supplier, the supplier is indifferent and the customer trusts the supplier can be described in this framework by situation 2 at supplier's side (left part of Figure 5.5), combined with situation 4 at customer's side (right part of Figure 5.5). Globally, an overall situation of cooperation will so be identified by the combination of the customer's situation and supplier's situation. We are going to specify these cooperation situations in the next part.

2.2.1 Distrusting partners

In each graph of Figure 5.5, the bottom line represents situations of distrust between supply chain members, which has very different consequences according to who holds the power.

Situation 1 at supplier's side may be considered as favorable for the supplier, since the lack of trust may be compensated by his own power over the customer. This is a way to prevent opportunistic behaviors (Liu et al., 2010). The symmetric situation is Situation 6 at customer's side. Due to his power over the supplier, the customer could control his supplier and impose his own objectives or constraints, which may reduce the risks coming from the relation with a distrusted supplier.

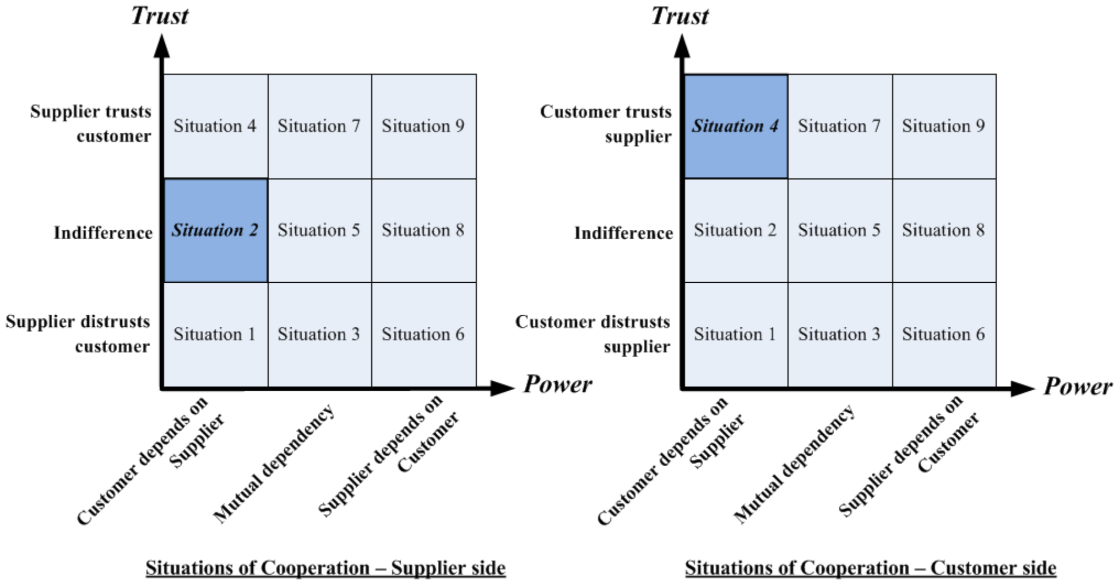

Figure 5.5. Taxonomy of customer and supplier situation

On the opposite, Situation 3 appears as rather unconformable on both sides, since the supply chain members, supplier or customer, are dependent on a distrusted partner. The behaviors become in this case rather unpredictable.

In Situation 6 at supplier's side and Situation 1 at customer's side, both companies will certainly try to decrease the risk of the relationship through precise contracts, allowing to compensate the lack of trust on a partner on which the company has no power. The main attitude between supply chain members will so certainly be the "no exception" policy (Möllering, 2003). No initiative outside the contract is expected from the distrusted partner.

2.2.2 Indifferent partners

The middle line of the two taxonomies, denoting an indifference between customer and supplier, is the perfect field for the so called "arm's length" policy (Forker and Stannack, 2000; Möllering, 2003). Like in the bottom line, the contract will be the base of the relationship, even if at a lower degree than for line 1, since the partner is not suspected to have a selfish (nor benevolent) attitude. Therefore, the balance of power and degree of interdependency will emphasize the interest of having a good customer-supplier relationship.

Situation 2 in both supplier's and customer's side may represent the situations in which supplier is more powerful and may impose his objectives and constraints in the contract. The symmetric situations are Situation 8 in both sides, the customer being a dominant partner who has more power to lead agreements and contracts.

2.2.3 Trusting partners

The top lines denote the trust of the considered company for his partner, either trust from the customer's side, from the supplier's side, or both. Trust allows to reject the "no exception" attitude (Möllering 2003) and decreases the level of required monitoring of the relationship (Andersen and Kumar, 2006). Relationship may become relatively informal while the contract is not anymore an absolute reference, with the result of a better flexibility and reactivity of the relationship, leading to the increased performance usually associated with trust (Johnston et al., 2004). In such situations, adverse impacts of imbalanced power may correspondingly be weak. Therefore, Situations 7 in the two sides can be considered as the ideal situation of cooperation, required for implementing the negotiation framework described in Chapter 4. Situation 4 and Situation 9 in both sides need more flexibility to deal with "exceptions" or "uncertainties" and the level of trust between customer and supplier would help to find mutual agreed solution for managing constraints.

2.2.4 Asymmetric trust between partners

In the suggested model, we consider that trust is asymmetrical, based on observations during the interviews. Therefore, combined situations crossing the previous three lines (distrust, indifference and trust) may exist in real cases.

Situation 4 at supplier's side and Situation 1 at customer's side represent a combined situation in which the supplier is a dominant partner and trusts his customer. However, the customer questions the supplier's behaviors on its service. On the opposite, Situation 1 at supplier's side and Situation 4 at customer's side is a situation in which the more powerful supplier distrusts its customer. Such relationship is obviously unstable since the supplier has the possibility (power) and motivation (distrust) to break the relationship.

Situation 9 at supplier's side and Situation 6 at customer's side is another unstable combined situation. The customer is the powerful partner but distrusts his supplier's capability to well satisfy his requirements. If the customer thinks that the situation can be improved, he may try to develop the competence of his supplier in order to increase his own trust, but this effort will certainly not be important if the supplier has no specific interest (which would have given him some power). On contrary, Situation 6 at supplier's side and Situation 9 at customer's side represent the combined situation in which a powerful customer trusts his supplier while the supplier doubts of the benevolence or goodwill of his customer. In such situation, the customer may have a poor motivation for taking into account the supplier's constraints, which may be the reason of the supplier's lack of trust.

3 Matching between real situations and suggested taxonomy

In this section, we will give some examples of real situations, as they were identified during the interviews, which will be positioned in our taxonomy (Ming et al., 2011).

3.1 Situations from the supplier point of view

We shall not consider here all the situations of the left part of Figure 5.5 one by one, but check how real situations may be positioned in the left table of Figure 5.5, sometimes with some accuracy, other times as a set of possible situations.

Many illustrations of situations linked to the right column of the left table of Figure 5.5 have of course been met during the interviews, since the power is usually on the customer's side, especially when the suppliers are SMEs. For instance:

- An already mentioned supplier wanted to create a close relationship with one of its important customers. In that purpose, he wanted to have a very good service ratio. Considering that the firm period of the forecasts was too low for being sure to be on time, he preferred to release the orders on the base of the flexible period sent by the customer, taking the risk that some cancellations may occur (situation : supplier trusts customer).

- The supply time of some alloys and casting parts used in the aeronautic industry may be long (up to 12 months). This supply time is often longer than the fixed period of the forecast. In that case, the supplier may send firm orders for the raw materials on the base of the flexible period of the forecasts, taking therefore a risk, denoting his trust for his customer (Situation 9). Some suppliers refused to do it, but did not dare to clearly discuss this issue with their customer, showing that they are in Situation 6. This led to delays, unexpected by the customer but perfectly foreseeable. Sometimes, the supplier refuses the situation and discusses possible issues with the customer: this attitude may denote Situations 1, 2, 3 or 5 (poor trust, balanced power or power on the supplier's side).

- Supplier development is a good way to assess trust. The SMEs have sometimes entered the programs under the insistence of their customer (right column: supplier depends on customer), but see this as a real opportunity (Situation 9: they trust their customer). In other cases, the suppliers have entered the programs while thinking that the methods on which they would be trained (MRP or Lean) were not applicable for them (Situation 6: they do not trust the customer, but depend on him). For some SMEs, lean manufacturing is indeed considered as a way used by their large customer for decreasing their autonomy: instead of giving priorities to the orders, some customers ask for instance their suppliers to process the orders in FIFO (Situation 6). In some cases, a real negotiation was engaged on the object of the training (denoting Situations 3, 5 or 8).

- Some customers know that their technical skills give them some power over their customers, but enter the development programs on a voluntary base in order to still increase the relationship (Situations 4 or 7).

- Similar figures were observed in another context: the large companies of the sector want to impose that their smaller suppliers buy production management systems (in order to be able to use the MRP method and to have a better visibility on the future). In addition, they ask for proofs of correct use of these systems (showing their distrust). Most of the time, the SMEs were very doubtful on the possible results, but accepted to buy and implement the products (Situations 6 or 8).

- In many cases, the suppliers group the orders sent by their customers in order to decrease their set-up times. In some cases, these groups were made without taking into account the due dates, with the result of early and tardy orders. For the suppliers, customers have slack times that they do not communicate, so these delays are not really important (bottom line of the matrix: no trust in the due dates). Nevertheless, they do not clearly discuss the problem with the customers, since they know this attitude would not be appreciated (Situation 6: dependence).

Column 1 (customer depends on the supplier) of course denotes more unusual situations. Nevertheless, the following cases were encountered:

- A small supplier has a very specific position in the supply chain of a large customer: he has a high and rare technical skill and very low costs, because of a light infrastructure. The customer wanted him to buy a production management tool, since his ratio of service was poor. The supplier refused: he was already overloaded, and the customer cannot find another supplier with comparable prices... The relationship is clearly here in Situation 1 or 2 for the supplier.

- A SME specialized in surface treatment has also a quite interesting position: its technical skills being rare (left column: the customer depends on him), it has been able to impose to its customers that the price of the treatments depends on the cycle time: if the parts are urgent, the customer has to pay more. Using that strategy, the supplier has seen a considerable decrease in the number of urgent parts, which was one of his goals (Situation 1: no trust in the urgency of the orders).

- Again on the urgency: since more than 30% of the orders he received were AOG according to its customers, a supplier located at the end of the process (therefore inheriting from all the upstream hazards) decided to systematically refer to the final assembler for checking the status of the parts. It appeared that 60% of the orders were not real AOG: the customers of tiers 1 or 2 were using this status for trying to increase their own ratio of service for their customer... (Situation 1: no dependence, no trust).

The situations of the middle line and column of the matrix are often considered as a goal by the suppliers. Indeed, people in SMEs usually trust persons more than organizations (see for instance (Andersen and Kumar, 2006) for investigations on the role of personal trust in SCM), but because of the turnover of the large companies, they prefer a relationship based on clear contractual bases than on a person-to-person agreement. Additionally, many of them do not want to depend too much on a customer, and as a consequence would prefer Situations 2 (which requires to have a specific interest for the customer) or 5.

Such balanced situations have also been identified in the process of answer to Requests For Quotation. The parts object of the request may be difficult to produce. For the suppliers, the reason is mainly that the designers at the customers' side have less technical competences than before, while for the customers, it is the sign of an increase of complexity of the parts. In this situation, some suppliers manage to negotiate with the customers, showing that they are in a situation of mutual dependency and that they want a clear contract (Situation 5: mutual dependency and indifference leading to emphasize the role of the contract). Others, who depend heavily on the customer but trust him, choose to answer to the request in spite of their doubts, considering that the customer will afterwards help them to industrialize the parts (Situation 7: mutual dependency and trust).

3.2 Situations from the customer point of view

The situations as seen by the customers have been identified by interviews of large companies, but also, indirectly, during discussions with the suppliers, and especially with SMEs. Many of the discussed problems indeed denote situations belonging to the bottom line (customer distrusts supplier) of the right table of Figure 5.5 (customer's point of view):

- A customer had some doubts on the ability of one of his suppliers to buy casting parts. In order to decrease the risk, the customer decided to create a safety stock and without notice to the supplier, ordered himself several parts to the supplier's supplier. The consequence was that the supplier of the casting parts, who was overloaded, preferred to fulfill the large company's demand. Therefore, the supplier was indeed unable to get the parts. It is interesting to notice that the customer had in that case created the situation he wanted to prevent. This denotes Situation 1 or 3: the customer clearly distrusts the supplier (bottom line), and would work with other suppliers if possible (therefore, Situation 6 is improbable).

- Proofs of trust can also be found: in order to give to one of his suppliers the information allowing him to manage his internal priorities, a customer was used to send his level of inventory together with the orders. In case of capacity problem, the supplier was able to decide which parts to prioritize, according to its customer's interest (Situation 4 or 7: the customer trusts the supplier, and does not dominate him).

- Many customers perform regular audits at their supplier's, in spite of the time lost by the supplier because of the multiplication of these audits: Situation 6 (the customer does not trust the supplier, who cannot refuse the audits).

- Situation 6 was also easy to identify when a representative of a large company claimed in a public meeting that the SMEs do not have to discuss the content of the development programs, since the large companies know what the best is for them...

- Situation 1 of the customer has already been illustrated by one of the examples detailed in previous section: the customer depends on its supplier because of his technical skills and low prices, but knows that he is not reliable.

- The criteria of selection of the suppliers are also a good way to identify a situation. In most cases, large companies want to represent a significant ratio of their supplier's income (for having some influence on them) but not too much (for being able to decrease their orders if needed without setting into question the viability of the supplier). This denotes a clear strategy to privilege situations belonging to the middle column. Their final goal is to work with reliable partners (by promoting the use of methods and tools allowing their partners to better manage their production): at least

Situation 5 is targeted (mutual dependency, indifference), even if Situation 7 is preferred (mutual dependency, the customer trusts the supplier).

- During the interviews, the large companies gave us many examples of problems coming (according to them) from the low level of competences of small companies on production management, leading to a global distrust on this aspect (middle line of the table). This is consistent with (Lenny Koh and Simpson, 2005) for instance, who points out the reluctance of small companies to invest on information technology, and more specifically on planning tools. At short term, this poor trust may be compensated by power in Situation 6. Nevertheless, even if the power of the supplier on his customer has only positive aspects for the supplier, the power of the customer on its supplier may create responsibility concerning the survival of the supplier. Therefore, Situation 3 (mutual dependency) is preferred to Situation 6 (the supplier depends on the customer).

- According to our experience, the link of large companies with SMEs seems to be often based on personal relationships, since the contact for the SME's is often the Director, who is usually very stable (the company belongs to him in many cases). Therefore, a SME has a reputation for a customer (good or bad) which is known by all the employees of the customer. As a consequence, large companies put a lot of emphasis on their trust on their small partners (mainly on the director) and less on the contracts. Such relationship is often unbalanced, the large companies being considered as unstable by the small ones, because of their turnover and perpetual restructuration. Indeed, trust is known as a condition for flexibility and adaptability (Andersen and Kumar, 2006), which are properties looked for by large customers, but not by small suppliers, looking for stability which can be brought by contracts.

4 Matching with the negotiation processes

As previously stated in Chapter 3, the suggested negotiation processes aim at helping to increase the performance of relationship by turning hidden problems into negotiation items, which may lead to a better supply chain cooperation. Nevertheless, it was clear that making these processes realistic requires an intensive exchange of information, including data usually considered as confidential, like internal lead time, capacity or costs. Nevertheless, the survey on the literature shows the potential impact of an increased trust between partners. Therefore, after analyzing the costs related constraints of the negotiation process in Chapter 4, we are going to go further, indicating the cooperation situation or supply chain relationships which are in our opinion consistent with the negotiation framework we have suggested.

The primary goals of our suggestion are to allow supply chain members to publish some hidden problems and address them in an open negotiation processes.

The first steps of the negotiation processes deal with detecting problems, which we consider as an initiative attitude. On the other hand, the negotiation on load variation and lot sizes triggered by the supplier is considered as a cooperative attitude, since it aims at publishing constraints and problems to the customer. The supplier's requested negotiation on price and cycle time is different, since fulfilling urgent orders is not the supplier's obligation. Thereby the negotiation on the price and cycle time is necessary for both customer and supplier. It appears to us that the different characteristics of these items lead to various relations with the cooperation situations as we identified them. We shall try in next section to match each negotiation process with the cooperation situations in which it may occur.

4.1 Customer's side

In the customer's point of view (see the right part of Figure 5.6), if the customer distrusts or feels indifference towards his supplier, a strict execution of the contract is certainly the common way to perform cooperation in the supply chain. In our proposals, except for price, cycle time and lot sizes, the other suggested items are usually fixed in contract. However, negotiation on these items needs a high level of trust. Even for urgent orders management, a complex issue which is outside the terms of the contract, good performance of negotiation on price and cycle time requires a long-term and better managed relationship, in which trust in a prerequisite. Thereby, we suggest to launch negotiation processes in the top line (customer trusts supplier). We have highlighted the corresponding cells with white background and numbered each negotiation process in Figure 5.6.

In Situation 9, the supplier depends on the customer. The load variation, changes and urgent orders on customer's side have very important effects on his supplier. At the same time, the supplier is trustworthy to fulfill the customer's requirements by doing all his best. Thereby, when customer's requirements are out of supplier's capabilities, and due to supplier's dependency on the customer, the supplier can hardly communicate his constraints to his customer. As a consequence, hidden problems may occur and poor delivery performance might exist. Therefore, it is the customer's role to launch the negotiation process when he detects possible problems, in order to avoid cooperation disturbance. We so suggest negotiation on load variation-customer request (④) and negotiation on lot sizes-customer request (⑧) in Situation 9. On the other hand, if the customer and the supplier are mutually dependent (Situation 7), these two negotiation processes are also very likely to be launched by the customer. Therefore, we locate ④ and ⑧ at the sideline of Situation 7 and Situation 9 (Figure 5.6, right part).

Negotiation on price and cycle time-customer request (⑥) may also be considered as a protection-oriented activity. The fulfillment of urgent orders is uncertain. The power of the customer (Situation 9) might prevent the supplier from communicating his constraints and real situation to his partner. However, it is not the case if the supplier is dominant (Situation 4), or even in the case of mutual dependency (Situation 7), since satisfying urgent orders is not an obligation for the supplier.

Negotiation on the period of forecast-customer request (②) targets at sharing risks with the supplier. It is not a protection activity but a communication problem dealing with benefits. At the customer's side, it concerns the horizon of firm period of forecast, which is fixed by contract. Therefore, it is clear that the dominant member has the power to launch such negotiation. Therefore, we put it into Situation 9.

In Situation 4, the customer depends on the supplier, since the supplier holds a dominant position, meaning that supplier's constraints become very important for the customer. In the meantime, the customer believes that his supplier would like to fulfill his obligations in the cooperation. Accordingly, the problems and constraints published by the supplier are real ones, which the supplier is not capable to overcome by himself. Therefore, the customer should contribute to solving these problems. As a consequence, we suggest negotiation on orders priorities (⑨) in Situation 4. Even in a mutual dependency (Situation 7) ⑨ would also be launched due to the trustfulness of the customer towards his supplier. Therefore, we locate ⑨ at the sideline of Situation 4 and Situation 7.

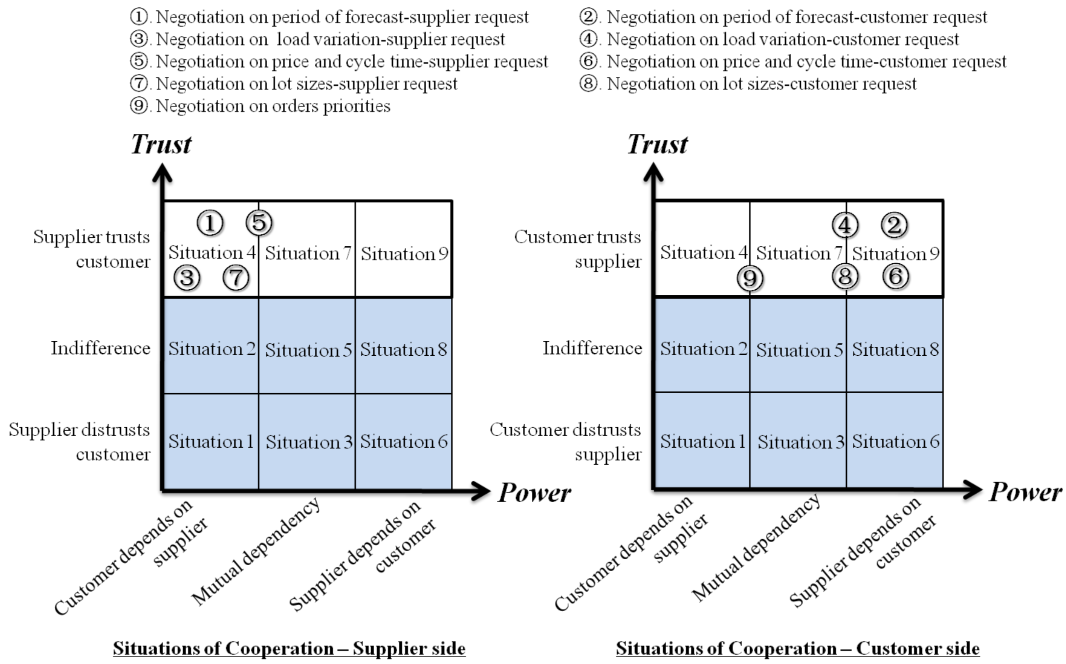

Figure 5.6. Matches of negotiation process and cooperation situation

4.2 Supplier's side

In our opinion, if the supplier distrusts or feels indifference towards his customer, the contract will be the base of the cooperation, whereas a strict execution of the contract is in our opinion a barrier against a better cooperation and negotiation on the occurring problems. Therefore, we also limit our suggested negotiation processes to the top line (supplier trusts customer) (see the left part of Figure 5.6).

From the supplier's point of view, things are less complex, since negotiations launched by the supplier are always aiming at publishing operational problems, except for the negotiation on period of forecast-supplier request (①). As previously mentioned, this case needs power to re-allocate risks between customer and supplier. Thereby, we suggest to locate ① in Situation 4.

In the situations of the top line, the supplier trusts his customer, believing that the customer will be ready to take into account his constraints and perform protection-oriented activities. Accordingly, when the customer is more powerful (Situation 9), protection-oriented negotiation would be launched by the customer and the constraints on the supplier side would be openly communicated to the supply chain. Therefore, in our proposal, it is supplier's duty to publish his real constraints and possible problems towards his customer, when the supplier's delivery performance has critical effects on the customer (Situation 4), while the customer might not see these hidden problems, due to the power of the supplier. As a consequence, we suggest negotiation on load variation-supplier request (③) and negotiation on lot sizes-supplier request (⑦) in Situation 4.

For similar reasons, negotiation on price and cycle time-supplier request (⑤) is proposed in Situation 4, as well as in the situation of mutual dependency (Situation 7). For us, only the power from the customer (Situation 9) might prevent to launch ⑤. Therefore, we put ⑤ at the sideline of Situations 4 and 7.

So far, the presented matches between the suggested negotiation processes and cooperation situations are only theoretical considerations. Other matches may also exist, depending on specific cases. Furthermore, the cooperation situation between customer and supplier is not static but dynamic, according to evolutions linked to the real performance of cooperation. For instance, decrease of the cycle time by the supplier due to new investments may bring this supplier to a more dominant position; long lasting satisfactory delivery performance from the supplier's side may lead to a more trustful and stable relationship between supplier and customer. On the opposite, poor performance or selfish behavior by one of the partners will inevitably result in a decrease of trust. Thereby, the evolution of the situations is not only a factor that impacts the results of negotiation, but also, at middle or long term, an output of the negotiation process.

5 Evolution of the situations

The situations of cooperation are clearly object of an evolution, controlled or not. We do not try here to make an exhaustive list of possible evolutions, but we shall emphasize that the suggested typology may help to have a better view on the situations and problems which may occur. Meanwhile, an efficient negotiation based on mutual consideration and information sharing may lead to a positive evolution of the situations. Since many different cases may occur, we shall only describe here typical evolutions as an illustrative example (see Figure 5.7).

On the supplier side, a relationship typically begins in Situation 8 (or Situation 5 if the supplier has some rare competence or even Situation 2 if he has a critical one). In a more or less formalized way, the goal of the supplier will be to evolve from the right column to the central one, providing a better balance of power (arrow 1 in the supplier matrix). In that purpose, the supplier may rely on his technical skills (by becoming competent on processes which are important for his customer), or on other aspects of performance which are also important for his customer (reliability or reactivity for instance).

Typically, the customer is in Situation 8 at the beginning of the relationship (he has preferably chosen a customer on whom he has some power). In order to increase the reliability of his supplier, he will eventually suggest him a supplier development program. If the supplier accepts and if the program is a success (i.e. the performance indicators of the supplier evolve positively), the situation may evolve from 8 to 9 (increase of trust). Nevertheless, if the supplier has succeeded in creating a privileged relationship, the arrival situation can be 7 (mutual dependency), either directly (arrow 3) or indirectly (arrows 2 and 4, related with negotiation). If the development program is a success, and if the supplier gets rewards (new orders, etc.), it is probable that trust from the supplier towards his customer will increase in parallel (arrival in Situation 7 by arrow 5 on the supplier matrix).

On the other hand, the evolution of the situation may be less favorable. If the performance of the customer through time is low, his customer will pass from Situation 8 to Situation 6 (arrow 6 - distrust), which is highly unstable (there is no interest to keep a distrusted partner if he is not critical). As seen in the previous sections, in some rare cases, the customer may also move to Situation 3 (arrow 7) or even 1 (arrow 8) (denoting that even if part of his performance is poor (on the reliability for instance), the supplier has gained some power on the customer (often through critical competences or low prices)).

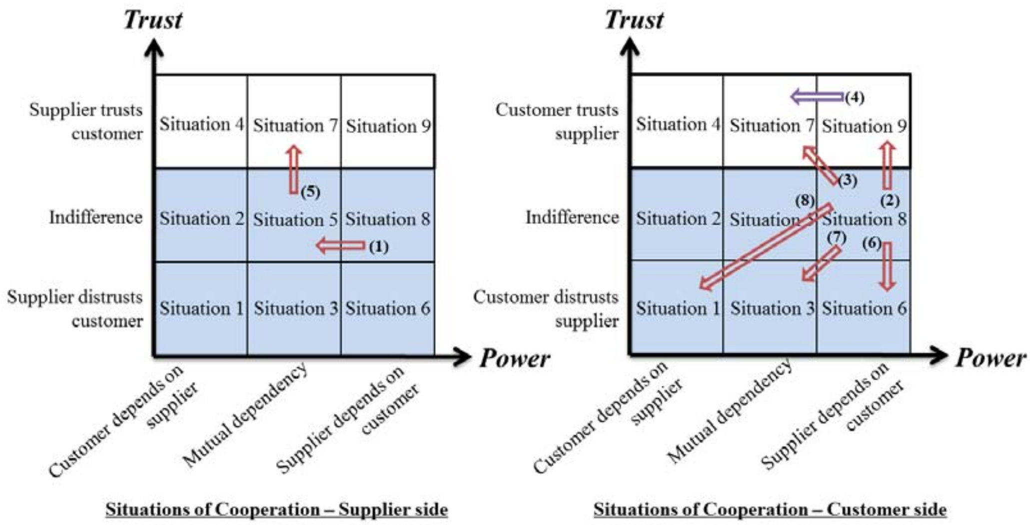

Figure 5.7. Classical evolutions of the situations of cooperation

6 Conclusion of chapter 5

In this chapter, we firstly introduced a literature survey on cooperation situations focusing on the behavioral/qualitative aspects, which are strongly influenced by the type of customer-supplier relationship. We have then analyzed in more details the factors that directly influence the different types of relationships in a supply chain. Among these factors, trust, commitment, power and dependency are the most widely considered in the literature. Many works have showed that these factors may influence others, like trust could impact the levels of commitment, informal agreement, willingness to cooperate, communication, information sharing, opportunistic actions and so on.

We have also analyzed some existing taxonomies, which provide different solutions for classifying supply chain relationships, using one or several factors. Some taxonomies appear to be too simple for describing the situations seen during our case studies, whereas others may be questioned by their choice of dependent axes, such as trust and commitment, which are often considered as linked. Additionally, existing taxonomies are generally using simple levels like high/low for describing their factors.

In this context, we have suggested a taxonomy with two dimensions, trust and power. These two factors are widely used, and have rather independent relations. Afterwards, we have tried to define levels allowing to address positive, neutral and negative levels of the considered factors. For the dimension of power, we made the hypothesis that power is a symmetrical feeling for both customer and supplier, since power is more relevant than dependency, which may also be considered as symmetrical in supply chains. Therefore, at the first step, the proposed levels of power have been defined as “the customer depends on the supplier", "the supplier depends on the customer" and "mutual dependency". For the dimension of trust, we proposed to consider the possibility of an asymmetrical relationship, since customer and supplier may hold quite different criteria for giving their trust towards the other. Besides, we define "distrust", "indifference", and "trust" as the levels of trust at both customer and supplier side, assessed independently.

The suggested taxonomy provides a model of cooperation situations. From both customer and supplier side, there are nine different cooperation situations. Some of these situations have already been observed in chapter 2 and are consistent with the negotiation process suggested in chapter 3. Therefore, we matched the suggested negotiation processes with these situations, trying test the usefulness of the taxonomy of the cooperation situations, on the opposite for locating the situations requited by the negotiation processes. Finally, we briefly presented some possible evolutions of the situations, showing that the suggested typology may help to have a better view on the dynamics of the relationship.

Conclusion

Cooperation between partners within supply chains is becoming more and more important for nowadays enterprises. In that context, classical problems deal with how to synchronize local and global objectives, in a way which satisfies all the SC members. From case studies, we have shown that large companies have set a huge effort on promoting processes suggesting “best practices” through supplier development in their supply chains. However, SMEs may have difficulties for adopting these rather rigid frameworks, due to their specificity but also to local constraints, which may be hidden or under-estimated by their customers. Furthermore, the literature on supply chain so that our own experience show that the performance of cooperation in a supply chain context is not only a technical problem, but requires as a pre-requisite given attitudes like trust, power, commitment, dependence, etc. Based on this context, we suggest negotiation processes for a cooperative supply chain, aiming at turning some of the usually hidden constraints into negotiable items, leading to a better risk sharing between partners, and helping supply chain members to achieve win-win cooperative situations.

The basic ideas contained in our proposal come from cases studies in the aeronautic industry. If the relatively low number of visited companies does not allow to fully guarantee the generality of the identified problems and situations, it is consistent with the results of previous projects on the same domain (see for instance (Affonso, 2008)) and shows that some existing problems are not yet fully taken into account by the practices which are presently promoted by large companies.

Negotiation processes have been suggested in relation with four items: periods of forecast, load variation, price and cycle time, and order priority and lot sizes. These items are not a closed list of what can be negotiable but aim at providing examples of the fact that, paradoxically, taking into account the partner’s constraints may in some cases finally lead to a win-win situation. Brief introductions of the suggested negotiation processes are presented in form of Business Process Diagram and detailed activities in each process are addressed through UML Sequence Diagram, showing some typical scenarios on use cases of the negotiation processes.

In order to make our suggestion realistic, we have firstly specified the detailed processes and then test their practical feasibility, on one hand through the assessment of extra costs and on the other hand matching them with identified cooperation situations, in which such negotiation process may exist. The extra cost assessment concerning the results of negotiation allows to check whether the negotiation is feasible and beneficial and provides cost-based constraints allowing to better understand when such processes may be of interest. From the behavioral point of view, realistic negotiation processes depend on the current holding relationship between the supplier and the customer. Opportunistic behaviors, exaggerated constraints publishing, untrue information sharing, etc. are inevitably barriers towards our proposal. Therefore, we have identified the situations in which the suggested negotiation process would be better performed, showing the behavioral constraints which should be satisfied as a pre-requisite to negotiation.

Despite the fact that our suggestions may seem to be against the common industrial habits (including e.g. continuous negotiation on prices and cycle times), the suggested negotiation processes are quite consistent with some practices identified during the industrial interviews. In any case, our goal is not to suggest a so-called “optimal” negotiation process, but to take some real empirical situations from case studies as examples, and try to include them into a consistent formal negotiation process, in order to check their real potential. Furthermore, the numerical simulations of cost assessment and the identified suitable cooperation situations are first elements showing the potential interest of the suggested cooperative processes.

The negotiation processes we presented in this thesis are not yet mature models; improvements are surely necessary, for instance for adding more negotiable items, formalizing the triggers of each negotiation process and specifying with more details the information required to perform the processes. In addition, we have briefly presented cost-related constraints helping to better understand when negotiation could be beneficial. However, more factors should be taken into account in real applications. For instance, after balancing total cost and benefits, it may be shown to the supplier that, according to purely quantitative indicators, it is more beneficial to delay an order. However, cumulative delays over a long term horizon will inevitably impact the performance indicators of the supplier and also the degree of trust from his customer. Therefore, balancing different quantitative factors with more qualitative ones should be added into the negotiation process.

From the technical point of view, a multi-agent based approach would be a good way to implement the negotiation processes in order to validate them more thoroughly, and would also allow to eventually transform the suggested negotiation processes into a business intelligence system. Locally, the basic requirements are to allow the agents to access the information they need through the ERP system, using as forecast, load, inventory level, etc. and to send back the results of the negotiation into the ERP/MRPII system (e.g., new lead times, new costs, etc.). On the other hand, due to the autonomy of the supply chain members, it is not realistic that the agents at the supplier would access all the information on the customer’s side, but more likely that they can communicate with other agents on the customer’s side. Therefore, agents should be located locally, access local information, receive externally sent information and communicate with the agents on the other side. Since the information systems at the supplier and the customer are usually different, the agents on both sides could be themselves slightly different, which may lead to have to consider some problems linked to interoperability.

We are conscious that the suggestions discussed in this thesis may be considered as a way to cope with “bad habits” instead of eliminating them. In a meeting where suppliers and customers were supposed to discuss on cooperation issues, we have for instance heard a representative from large companies saying that discussing what could be done in the SMEs was not of interest, since the good methods to disseminate were all known. Nevertheless, we do think that one of the objectives of a research work may be to consider other ways of thinking than those which are widely accepted. We would have reached our objective if this work opens new discussions on the subject.

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Appendix: Detail simulation of the negotiation process

In this appendix, we present all the numerical simulations of each scenario in the practical illustrations of negotiation process in chapter 4.

Appendix I: Period of forecast, Normal case 1, forecast, in the month of January

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May
Sales Forecast			80	60	60
Firmed Orders	60	80			
Desired Stock					
Sales Plan	60	80	80	60	60
	Jan.	Feb.	Mar.	Apr.	May
Production Plan	60	90	90	60	60
Projected Stock	10	20	30	30	30

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A																												
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	10	15	15	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	15	0	15	25
MO receipt									30		30		30	30		30	30		30	30		30		30			30	30
MO release					30		30		30	30		30	30		30	30		30		30			30	30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1																												
Gross requirement					30		30		30	30		30	30		30	30		30		30			30	30				
Projected stock (20)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	20	30	0	0	0	0	0
Net requirement																												
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12								
PO receipt					40		40		40			40	40		40			40		40			40					

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40			40		40			40					
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40			40					
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40			40					
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40			40					
Projected stock (20)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	30	30	30	40	40	40	40	40	40
MO receipt					50		50		50			50			50			50		50			50					
MO release			50		50		50			50			50			50		50			50							

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50		50			50							
Scheduled receipt																												
Projected stock (30)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	10	10	10	20	20	20	20	20	20	20	20
Net requirement			60		60		60			60			60					60			60							
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60			60													

Appendix II: Period of forecast, Normal case 1, scenario 1.1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast			80	60	60	70
Firmed Orders	60	80				
Desired Stock						
Sales Plan	60	80	80	60	60	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	60
Projected Stock	10	20	30	30	30	20

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	10	15	15	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	15	0	15	25	10	25	5	15
MO receipt									30		30		30	30		30	30		30	30		30		30			30	30		30		30
MO release					30		30		30	30		30	30		30	30		30		30			30	30		30		30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	20	30	0	0	10	10	20	20	20	20	20
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40			40			40		40				

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																		40		40			40			40		40
Firmed Orders					40		40		40			40	40		40													
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40			40			40		40
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40			40			40		40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40			40			40		40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	30	30	30	40	40	40	0	50	10
MO receipt					50		50		50			50			50			50		50			50				50	
MO release			50		50		50			50			50			50		50			50				50			

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50		50			50				50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	10	10	10	10	10	10	10	20	20	20	20
Net requirement			60		60		60			60			60					60			50				60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60			50				60									

Appendix III: Period of forecast, Normal case 1, scenario 1.2

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	60			
Desired Stock						
Sales Plan	60	80	60	60	80	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	60	60	90	60
Projected Stock	10	20	20	20	30	20

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**15**	**15**	**15**	**15**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	0	15	0	15	0	15	0	15	25	5	15	25	10	25	5	15
MO receipt									30		30		30	30		30		30		30		30		30	30		30	30		30		30
MO release					30		30		30	30		30		30		30		30		30	30		30	30		30		30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30		30		30		30		30	30		30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	10	20	20	30	30	0	0	10	20	20	30	0	0	10	10	20	20	20	20	20
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40		40		40				40	40		40			40		40				

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																				40	40		40			40		40
Firmed Orders					40		40		40			40		40		40												
Desired Stock																												
Sales Plan					40		40		40			40		40		40				40	40		40			40		40

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40		40		40				40	40		40			40		40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40		40		40				40	40		40			40		40
Projected stock (40)					10	10	20	20	30	30	30	40	40	0	0	10	10	10	10	20	30	30	40	40	40	0	0	10
MO receipt					50		50		50			50				50				50	50		50					50
MO release			50		50		50			50				50				50	50		50					50		

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50				50				50	50		50					50		
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	100	50	50	50	50	60	10	10	20	20	20	20	20	30	30	30
Net requirement			60		60		60			60			60					60			60					60		
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60			60					60								

Appendix IV: Period of forecast, Normal case 1, scenario 1.3

Manufacturer

S&OP

Period		Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast					60	80	70
Firmed Orders		60	80	100			
Desired Stock							
Sales Plan		60	80	100	60	80	70
		Jan.	Feb.	Mar.	Apr.	May	June
Production Plan		60	90	90	60	90	60
Projected Stock		10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**25**	**25**	**25**	**25**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	15	0	5	20	5	20	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30	20	10	30	30		30		30	30		30		30	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
														20	add 10																	

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	-10	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	40			40		40	40				40		40	40					
														0	add 40				20	add 10	add 10											

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																	40		40	40				40		40	40	
Firmed Orders					40		40		40			40	40	40														
Desired Stock																												
Sales Plan					40		40		40			40	40	40			40		40	40				40		40	40	
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40	40			40		40	40				40		40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40	40			40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	-40	10	10	20	20	-20	-10	40	40	40	0	0	10	20	20
MO receipt					50		50		50			50			50		50		0	50	50					50	50	
MO release			50		50		50			50			50		50		50		50					50	50			
																	0	add 50										

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50		50		50		50					50	50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	0	0	-50	10	20	20	20	20	20	30	40	40	40	40
Net requirement			60		60		60			60			60					60	60					60	60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60	60					60	60									

Appendix V: Period of forecast, Normal case 2, scenario 2.1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	60	70
Firmed Orders	60	80	80			
Desired Stock						
Sales Plan	60	80	80	60	60	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	60
Projected Stock	10	20	30	30	30	20

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	10	15	15	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	15	0	-15	-35	10	25	5	15
MO receipt									30		30		30	30		30	30		30	30		30		30			0	0	60	30		30
MO release					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
																							0	0	add 60							

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30			30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	0	0	0	-30	-60	0	10	10	20	20	20	20	20
Net requirement																																

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40			40			40		40				
																				20			0		add 60							

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40			40		40			40			40		40
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40			40			40		40

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40			40			40		40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40			40			40		40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	-20	-20	-20	-60	-60	0	-40	-40	-80
MO receipt					50		50		50			50			50			50		0			0		60			0
MO release			50		50		50			50			50			50		50			50					50		
																		0			0		add 60			0		

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50		50			50					50		
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	-50	-50	-50	-100	-100	-40	-40	-40	-90	-30	-30
Net requirement			60		60		60			60			60										60				60	

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60										60				60				60			

Appendix VI: Period of forecast, Normal case 2, scenario 2.2

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	60			
Desired Stock						
Sales Plan	60	80	60	60	80	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	60	60	90	60
Projected Stock	10	20	20	20	30	20

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**15**	**15**	**15**	**15**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	0	15	0	15	0	15	0	15	25	5	-15	-35	10	25	5	15
MO receipt									30		30		30	30		30		30		30		30		30	30		0	0	60	30		30
MO release					30		30		30	30		30		30		30		30		30	30		30	30		30		30				
																							0	0	add 60							

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30		30		30		30		30	30		30	30		30		30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	10	20	20	30	30	0	0	10	0	0	-30	-60	0	10	10	20	20	20	20	20
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40		40		40				40	40		40			40		40				
																					20		0		add 60							

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast														40		40				40	40		40			40		40
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40		40		40				40	40		40			40		40

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40		40		40				40	40		40			40		40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40		40		40				40	40		40			40		40
Projected stock (40)					10	10	20	20	30	30	30	40	40	0	0	10	10	10	10	20	-20	-20	-60	-60	0	0	0	-40
MO receipt					50		50		50			50				50				50	0			0	60	40		
MO release			50		50		50			50				50				50	50			50						
																			0			0	add 60	add 40				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50				50				50	50			50						
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	100	50	50	50	50	0	-50	-50	-50	-100	-40	20	20	20	20	20
Net requirement			60		60		60			60			60										60	60				
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60										60	60										

Appendix VII: Period of forecast, Normal case 2, scenario 2.3

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	100			
Desired Stock						
Sales Plan	60	80	100	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	90	60
Projected Stock	10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**25**	**25**	**25**	**25**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	15	0	5	20	5	20	5	-15	-35	-55	-75	-30	5	15	-5
MO receipt									30		30		30	30		30	30	20	10	30	30		30		0	0		0	60	50	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
														20	add 10						0	0		0	add 60	add 20						

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	-10	30	0	10	10	0	0	-30	-60	-60	-90	-30	0	10	10	10	10	10	10
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	40			40		40	40				40		40	40					
														0	add 40				20	0				0	add 60	add 20	0					

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40	40			40		40	40				40		40	40	
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40	40			40		40	40				40		40	40	
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40	40			40		40	40				40		40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Item A-1																													
Firmed Orders					40		40		40			40	40	40			40		40	40				40		40	40		
Projected stock (40)					10	10	20	20	30	30	30	40	0	-40	10	10	20	20	-20	-60	-60	-60	-60	-100	-40	-20	-60	-60	
MO receipt					50		50		50			50			50		50		0	0					60	60	0		10
MO release			50		50		50			50			50		50		50	50					0	50	50		10		
																	0	0					add 60	add 10	0		add 10		

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50		50		50	50						50	50		10	
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	0	0	-50	-100	-100	-100	-100	-100	-40	-30	-80	-80	-30	-30
Net requirement			60		60		60			60			60										60	60			60	
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60										60	60			60				60	60		

Appendix VIII: Period of forecast, Negotiation case 1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	100			
Desired Stock						
Sales Plan	60	80	100	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	90	60
Projected Stock	10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**25**	**25**	**25**	**25**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	-5	0	5	20	5	20	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30		30	30	30		30		30	30		30		30	30	
MO release					30		30		30	30		30	30		30	30	30		30		30	30		30		30	30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
PO receipt					40		40		40			40	40		40		40		40	40				40		40	40					
																			20	add10	add 10											

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40		40		40	40				40		40	40	
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40		40		40		40	40				40		40	40	
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40		40		40	40				40		40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40		40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	20	20	-20	-10	0	40	40	20	50	10	20	20
MO receipt					50		50		50			50			50		50		0	50	10	40		20	30		50	
MO release			50		50		50			50			50		50		50		50			50			50			
																	0	add 50	**10**	add 40		20	add 30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50		50		50		50			50			50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	0	0	-50	10	-40	20	20	-30	30	90	40	40	40	40
Net requirement			60		60		60			60			60					60		60			60	60				
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60		60			60	60										

Appendix IX: Period of forecast, Negotiation case 2

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	100			
Desired Stock						
Sales Plan	60	80	100	60	80	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	90	60
Projected Stock	10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**25**	**25**	**25**	**25**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	15	0	5	20	5	15	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30	20	10	30	30		25	5	30	30		30		30	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
														20	add 10				25	add 5												

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	-15	25	35	5	5	-5	55	25	35	35	5	5	15	25	25	25	25	25	25
Net requirement																																

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt					40		40		40			40	40		40	40			40	40		40				40	40	
																			20	add 20								

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40	40			40	40		40				40	40	
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40		40	40			40	40		40				40	40	

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40	40			40	40		40				40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40	40			40	40		40				40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	20	20	20	-20	10	20	40	70	70	70	80	40	40
MO receipt					50		50		50			50			50	50			0	50	10	60	30			50		
MO release			50		50		50			50			50	50			50		50	50				50				
																	0	add 50	10	add 10	add 30							

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50	50			50		50	50				50				
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	0	0	0	-50	10	-40	-30	30	30	30	40	40	40	40	40
Net requirement			60		60		60			60			60					60		60	60			60				

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60		60	60			60										

Appendix X: Load Variation, Normal case 1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	100			
Desired Stock						
Sales Plan	60	80	100	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	90	60
Projected Stock	10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	25	25	25	25	15	15	15	15	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	25	0	5	20	5	20	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30	30		30	30		30		30	30		30		30	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	30	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	40			40		40	40				40		40	40					
																			20	add 10add 10												

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																	40		40	40				40		40	40	
Firmed Orders					40		40		40			40	40	40														
Desired Stock																												
Sales Plan					40		40		40			40	40	40			40		40	40				40		40	40	
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40	40			40		40	40				40		40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40	40			40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	20	20	-20	-10	40	40	40	0	0	10	20	20
MO receipt					50		50		50			50		$\boxed{40}$	10		50		0	50	50					50	50	
MO release			50		50		50			50		$\boxed{40}$	10		50		50		50					50	50			
																	0	add 50										

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50		40	10		50		50		50					50	50			
Scheduled receipt																												
Projected stock (0)	0	0	10	10	20	20	30	30	30	40	40	0	50	50	0	0	-50	10	20	20	20	20	20	30	40	40	40	40
Net requirement			60		60		60			60			60					60	60					60	60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60	60					60	60									

Appendix XI: Load Variation, Negotiation case 1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	100			
Desired Stock						
Sales Plan	60	80	100	60	80	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	90	60
Projected Stock	10	20	10	10	20	10

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																	20	20	20	20					10	15	15	20				
Firmed Orders									15	15	15	15	20	20	20	20	**25**	**25**	**25**	**25**	15	15	15	15	**20**	**20**	**20**	**20**	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	20	25	0	5	20	5	20	5	15	25	5	15	0	15	25	5
MO receipt									30		30		30	30		30	30	30		30	30		30		30	30		30		30	30	
MO release					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30	30		30	30		30		30	30		30		30	30					
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	10	30	0	10	10	0	50	30	0	0	10	10	20	30	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40	$\boxed{20}$	$\boxed{20}$		40		40	40				40		40	40					
																			20	add 10	add 10											

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast															20		40		40	40				40		40	40	
Firmed Orders					40		40		40			40	40	20	20													
Desired Stock																												
Sales Plan					40		40		40			40	40	20	20		40		40	40				40		40	40	

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40	20	20		40		40	40				40		40	40	
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1														**40**														
Firmed Orders					40		40		40			40	40	20	20		40		40	40				40		40	40	
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	20	20	-20	-10	40	40	40	0	0	10	20	20
MO receipt					50		50		50			50		$\boxed{\mathbf{20}}$	30		50		0	50	50					50	50	
MO release			50		50		50			50		$\boxed{\mathbf{20}}$	30		50		50		50					50	50			
																	0	add 50										

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50		20	30		50		50		50					50	50			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	20	50	50	0	0	-50	10	20	20	20	20	20	30	40	40	40	40
Net requirement			60		60		60			60			60					60	60					60	60			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60	60					60	60									

Appendix XII: Price and cycle time, Normal case 2

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May
Sales Forecast			80	60	80
Firmed Orders	60	80			
Desired Stock					
Sales Plan	60	80	80	60	80

	Jan.	Feb.	Mar.	Apr.	May
Production Plan	60	90	90	60	60
Projected Stock	10	20	30	30	10

MPS

30 urgent

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A																												
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	20	20	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	5	15	25	5
MO receipt									30		30		30	30		30	30		30	30		30		30		30	30	
MO release					30		30		30	30		30	30		30	30		30		30		30	30					

30 urgnet

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1																												
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30					
Projected stock (20)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	30	0	0	0	0	0	0
Net requirement																												
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12								
PO receipt					40		40		40			40	40		40			40		40		40						

Supplier

S&OP

30 urgnet

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast													40		40			40		40		40						
Firmed Orders					40		40		40			40																
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40		40						
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40		40						
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40		40						
Projected stock (20)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	30	30	40	40	40	40	40	40	40
MO receipt					50		50		50			50			50			50		50		50						
MO release			50		50		50			50			50			50		50		50								

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50		50		50								
Scheduled receipt																												
Projected stock (30)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	10	10	20	20	20	20	20	20	20	20	20
Net requirement			60		60		60			60			60					60		60								
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60		60														

Appendix VIII: Order priority, Normal case

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	80			
Desired Stock						
Sales Plan	60	80	80	60	80	70

	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	90
Projected Stock	10	20	30	30	10	30

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	20	20	10	10	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	5	-5	15	35	15	25	35	15	30	15	25	35
MO receipt									30		30		30	30		30	30		30	30		10	30	30		30	30		30		30	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
																		10	add 30													

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	-20	10	0	20	30	0	0	10	10	20	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																		10	add 30	20	add 20											

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																		40		40		40			40		40	40
Firmed Orders					40		40		40			40	40		40													
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40		40			40		40	40

	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40		40			40		40	40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40		40			40		40	40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	10	-30	20	-20	30	40	40	40	0	0	10	20
MO receipt					50		50		50			50			50				50		50	50					50	50
MO release			50		50		50			50			50				50		50	50					50	50		

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50				50		50	50					50	50		
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	50	0	60	10	20	20	20	20	20	30	40	40	40
Net requirement			60		60		60			60			60					60		60					60	60		
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60		60					60	60								

Appendix XIV: Order priority, Negotiation case

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	80			
Desired Stock						
Sales Plan	60	80	80	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	90
Projected Stock	10	20	30	30	10	30

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	20	20	10	10	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	5	15	5	25	5	15	25	5	20	5	15	25
MO receipt									30		30		30	30		30	30		30	30		30		30		30	30		30		30	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	0	20	30	0	0	10	10	20	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																				20	add 20											

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																		40		40		40			40		40	40
Firmed Orders					40		40		40			40	40		40													
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40		40			40		40	40
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40		40			40		40	40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40		40			40		40	40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	10	10	10	20	20	-20	30	40	40	40	0	0	10	20
MO receipt					50		50		50			50			50			50			50	50					50	50
MO release			50		50		50			50			50			50			50	50					50	50		

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			50			50			50	50					50	50		
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	50	50	50	0	0	60	10	20	20	20	20	20	30	40	40	40
Net requirement			60		60		60			60			60					60		60					60	60		
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60		60					60	60								

Appendix XV: Order grouping, Normal case 1

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	80			
Desired Stock						
Sales Plan	60	80	80	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	90
Projected Stock	10	20	30	30	10	30

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	25	5	15	25	5	20	5	15	25
MO receipt									30		30		30	30		30	30		30	30		30		30		30	30		30		30	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	20	20	30	0	0	10	10	20	30	30	30	30	30
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																		40		40		40			40		40	40
Firmed Orders					40		40		40			40	40		40													
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40		40			40		40	40
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40		40			40		40	40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		$\boxed{40}$			$\boxed{40}$		40		40			40		40	40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	40	40	40	0	0	40	40	0	0	0	40	40	0	40
MO receipt					50		50		50			50			80					80					80			80
MO release			50		50		50			50			80					80					80			80		

Appendix XVI: Order grouping, Normal case 2

Manufacturer

S&OP

Period	Jan.	Feb.	Mar.	Apr.	May	June
Sales Forecast				60	80	70
Firmed Orders	60	80	80			
Desired Stock						
Sales Plan	60	80	80	60	80	70
	Jan.	Feb.	Mar.	Apr.	May	June
Production Plan	60	90	90	60	60	90
Projected Stock	10	20	30	30	10	30

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Item A																																
Firmed Orders									15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	20	20	20	20	15	15	20	20
Projected stock (5)								5	20	5	20	5	15	25	5	15	25	5	15	25	10	25	10	5	-15	15	25	5	-10	-25	15	25
MO receipt									30		30		30	30		30	30		30	30		30		**10**	0	50	30	0	**0**		60	30
MO release					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
																				10		add 20			0		add 30					

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Component A-1																																
Gross requirement					30		30		30	30		30	30		30	30		30		30		30	30		30		30	30				
Projected stock (10)				0	10	10	20	20	30	0	0	10	20	20	30	0	0	10	10	-20	-20	30	0	0	-30	-30	20	-10	-10	-10	-10	-10
Net requirement																																
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
PO receipt					40		40		40			40	40		40			40		40		40			40		40	40				
																				0		add 40			0		add 40	0				

Supplier

S&OP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales Forecast																		40		40		40			40		40	40
Firmed Orders					40		40		40			40	40		40													
Desired Stock																												
Sales Plan					40		40		40			40	40		40			40		40		40			40		40	40
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production Plan					40		40		40			40	40		40			40		40		40			40		40	40
Projected Stock																												

MPS

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item A-1																												
Firmed Orders					40		40		40			40	40		40			40		40		40			40		40	40
Projected stock (40)					10	10	20	20	30	30	30	40	0	0	40	40	40	0	0	-40	-40	0	0	0	-40	-40	0	-40
MO receipt					50		50		50			50			**80**							**80**					80	
MO release			50		50		50			50			**80**							**80**					80			

MRP

Period	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Component A-1-1																												
Gross requirement			50		50		50			50			80							80					80			
Scheduled receipt																												
Projected stock (40)	0	0	10	10	20	20	30	30	30	40	40	40	20	20	20	20	20	80	80	0	0	0	0	0	0	0	0	0
Net requirement			60		60		60			60			60					60							80			
	41	42	43	44	45	46	47	48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PO receipt				60			60					60							80									